



516 Harvey (W.) Anatomical Exercises concerning the Motion  
of the Heart and Blood, 2 vol. in 1, with the cancelled  
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1655

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See p 100 "Smaller"

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THE  
ANATOMICAL  
Exercifes of  
Dr. *WILLIAM HARVEY*  
Profeflor of Phyfick,  
AND  
Phyfician to the Kings Majesty,  
Concerning the motion of the *Heart*  
and *Blood*.

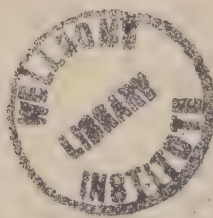
WITH  
The Preface of *Zachariah Wood*  
Phyfician of *Roterdam*.

To which is added  
Dr. *James De Back* his difcourfe of the  
*Heart*, Phyfician in ordinary to the  
Town of *Roterdam*.

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LONDON, Printed by *Francis Leach*,  
for *Richard Lowndes* at the *White Lion* in *St.*  
*Pauls Churchyard*, near the *West end*,

29280





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LONDON,  
Printed by *Francis Leach* as thought  
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*ZACHARIE WOOD* upon Doctor  
*WILLIAM HARVEY*.

**L**ong *Aristotle*, long may *Galen* live,  
Whose great renown all ages shall survive,  
And long live *Harvey*, they the Arts did find,  
Which this brave Englishman now has refind.







*The Preface of* ZACHA-  
RIE WOOD, *Physician*  
*at Roterdam, upon the Anato-*  
*mical exercise of Doctor* WIL-  
LIAM HARVEY.



It is a memorable story which is related by one *Aventine* a *Boian* Writer, That *Bonifacius* a certain Bishop of *Ments*, hearing *Virgilius* a Bishop of *Salesburg* in a Sermon which he made before the people of those times, make mention of those men whose footsteps tread opposite to ours, was so much incensed, that he did not stick to accuse *Virgil* of Blasphemie, as that having spoke of the Antipodes, he did seem plainly to aim at another Christ; and having related the businesse to *Utilio* King of the *Boii*, he procured the Letters of Pope *Zacharie* to *Utilio*, and so *Virgil* was both condemned by the Kings and the Popes Verdict. ¶ There is such another story related of *Democritus*, This *Democritus* being a diligent searcher of the works of Nature, whilst he was continually busied in cutting up of creatures, he was thought

*The Preface.*

mad by the *Abderitans*, who pitying the Mankind in that condition, called *Hippocrates* that he might give him Physick, and restore him to his lost wits; being desired, he came in all hast, and there he found *Democritus* cutting up of creatures, with which sight being marvelously taken, he avouch'd, That all the *Abderitans* were mad, and not a wise man but only *Democritus* amongst them. Now many men are like the *Abderitans*, there are now many *Bonifaces* and *Utilios* who do traduce the new inventions of those, who, as it were by the great inspiration of God, have bestowed all their studies upon the search and knowledg of things, as unprofitable, and the force of a custom once settled is able to effect so much, that no man in any barbarous place did ever seem to usurp more unlicensed power.

Doctor *William Harvey*, Kings Physician, and professor of Anatomy in the College of Physicians in *London*, has set out a new and unheard-of opinion concerning the motion of the heart, and circulation of the blood, which is briefly thus, First the ear of the heart contracts it self, in that contraction it thrusts out the blood contain'd in't into the ventricle of the heart, which being fill'd, the heart is dilated, and straightways it contracts the ventricles and makes a pulsation, by which pulsation it thrusts forth the blood thrown into it into the arteries out of the left ventricle, and out of the right into the lungs through the *vena arterialis* from whence immediately it is snatched into the left ventricle through the *arteria venosa*, and by this driven out into the *Aorta*, and so afterwards i



### *The Preface.*

the whole body through the arteries ; the blood so driven out into the habit of the body , passes from the arteries again into the veyns , and returns into the *vena cava* , and from it into the right ear of the heart , and then into the right ventricle , and so afterwards it passes through the same circle as before , and so continually , from whence he calls that motion of the blood Circulation. Truly a bold man indeed,

O disturber of the quiet of Physicians !

O seditious Citizen of the Physicall Commonwealth!

Who first of all durst oppose an opinion confirm'd for so many ages by the consent of all , and delivered up in the monuments of so many Physicians , and as it were given from hand to hand to posterity , as if no man had been wise in all ages past. Indeed they do very decently who worship antiquity as becomes them ; but it is a thing unworthy in wise men who do ascribe wisdom to antiquity , with no little wrong to posterity , as if it were not common to all times , and to all men ; for as *Lactantius* in the 2 Book of his Divine Constitutions , 8 chap. Because they had the precedency before us in time , they had not the precedency before us in wisdom , which , if it be given to all alike , it cannot be forestall'd by those that go before , but is untouchable as the light and clearnesse of the Sun ; for as the Sun is the light of the eyes , so wisdom is the light of mans heart. And truly , if those by whose benefit and study we have the invention and constitution of Physick , had been of

*The Preface.*

the same mind with these reprovers, & had thought nothing worthy publishing but what had been approved in the account and judgment of their Ancestors, such refin'd and elaborate arts had never come to light; but the antients knowing certainly that they had found out many things, some things likewise they had not perfectly enquir'd into, and that some were to them perfectly unknown, and believing that the way of searching out the truth was not stopp'd, but guarded for them by the example and diligence of antiquity, they did with ready minds endeavour that they might either go on in the same path with them, or passe beyond them in a further search. They did as it were advance the banner towards the search of hidden causes, and went before us in example, that we might follow them; for this is the liberty of wisdom, that being oblig'd to none, it's under it's own command and jurisdiction; in her Commonwealth it's permitted to abrogate, derogate, and search without prejudice to any, which liberty if we take away we shall always continue in the cradle of arts, nor will there be any thing from whence we hope for their increase, or for any thing better than has been published; for which cause we do require, that justice and courtesie in judgment maybe given of us which we afford to others; if the same thing be always to be thought and spoken it will not be lawfull to find out any new thing; nor must we take hold of what the very thing and reason it self dictates to us; tis ridiculous therefore to tread in the steps of the Antients

and



### *The Preface.*

and alwayes to follow them. Nor does *Galen* approve of any Anatomical Comment, unlesse it contain some new thing. It is a dull wit which is satisfied with that which others have invented, seeing all humane things are subjected to the sharpnesse of the mind. The treasures of Nature are immense, and her wisdom inexplicable, so that those things which dayly come abroad do prepare a way to search out those things which follow; for truth is drown'd in a deeper well than that it should be drawn out from thence in a few ages. It is true that *Aratus* said, That we were not taught all things at one time by *Jupiter*, but that a great many things do remain hid, of which some he will grant to us afterwards. *Galen* says, that the cunning of Nature in the fabrick of mans body is so great, that though great men have diligently and constantly searched after it, yet have they not found it all out.

*Long age, and divers travels in times change  
Have better'd it, nor all those Whom we range  
Amongst the Antients know what we do know,  
Young men somethings to observation owe.*

Therefore since to be wise, that is to say, to search after the truth, is born with all men, they take away all wisdom from themselves who without any judgment approve of their forefathers inventions, and are by them lead like Cattel, and do brag rashly, that they see those things in them which they do not see. The Comedy which uses to be acted by the Players looks much like this. By a certain  
cheating

*The Preface.*

cheating Taylor, there was a piece of excellen  
 cloath describ'd to an idle & simple Braggadochio  
 but of such a colour, that it could not be seen by  
 base begotten people or bastards; therefore this  
 Braggadochio desirous to buy, requires a sight of  
 the cloath; the Cheat presently as a huge piece ha  
 ving many els in it, brings it out in both his hands  
 as the Merchants use to do here, turns down the  
 folds, wonders at the fairnesse of it, prayses it  
 and commends it to his buyer; this vain Braggado  
 chio was presently touch'd with a suspition that his  
 Mother had play'd the Whore, yet shame hinder'd  
 him to confesse, therefore he sayes that he sees  
 and wonders at the cloath which he did not see  
 and indeed was not at all, and buyes it, and com  
 mands him to make him a Suit of it; then the Tay  
 lor began to be very merry, and joviall, divid  
 the cloath, imitates wonderfully the noyse of cu  
 ting it, and makes him up a garment of this fin  
 unseen and invisable cloath, receives his money  
 and gives it him. Believe me this fable in incred  
 lous men without judgment is a true history, and  
 no fable; they believe, and why should not they  
 give credit to Physitians approv'd by the judg  
 ments of so many ages? yet they do not see, nor  
 can they see, that which is not; yet lest they  
 should seem blockheads, they praise, admire, and  
 buy, not only with expence of money, whose da  
 mage is tolerable, but even with the losse of time  
 and life, the damage of which can be redeem'd  
 no money. Truly, that I may speak the truth  
 we must give lesse credit to authority, and we mu



### *The Preface.*

restrain our assent, and besides authority look after reason too by the example & authority even of antient Philosophers and Physicians; and first of all by the example of that divine *Plato*, whom *Cicero* so much esteems, that he does not stick sometimes to call him the *Homer* of Philosophers, sometimes a God; in whose book, O fortunate Sir ( says *Socrates* to *Polus* a young man who in his discourse concerning a blessed life produc'd testimony ) you endeavour to convince me as Orators do, and as they do in tryalls where they think that they foil one another when they bring many and famous Witnesses for their Cause, and the Defendant brings none, or some one, since this proof is of no consequence towards the truth; for many times a man is unjustly oppress'd, because of the multitude of witnesses, and of those too who seem to be of some worth & account: and so likewise in his *Charmides*, Nor is it to be considered who speaks, but whether truth be spoken or no; these and the like are every where in *Plato*. But let us hearken to *Aristotle* in this point, treading directly in his Masters footsteps, who, as he did not spare any of the antient Philosophers, no more did he *Socrates* and his Master *Plato*; for being to dispute against the Ideas, he says, Though it be a hard question, because that those who brought in the Ideas are our friends. yet it is necessary for the retaining of the truth to take off their opinions, especially they being Philosophers; for albeit they be both gallant men, yet it is a gallanter thing to honour the truth beyond them. Shall not we say that it is  
here

*The Preface.*

here clearly set down in what esteem the authority of the most grave Philosophers is to be had? when *Socrates* cries out, That *Hippocrates* and others witnesses evidences; and *Aristotle* cries out, That *Socrates* and *Plato*s evidences, are not so much to be weighed and esteemed as those of truth and reason; especially since *Cicero*, a man of divine quicknesse of wit, and singular judgment, who for the many prayes both of *Plato* and *Aristotle* may seem to have sworn allegiance to them both, did not unwillingly turn to the haven of the *Stoicks*, leaving the Academy of *Plato*, and the Lyceum of *Aristotle*. I do likewise believe that he would have passed over to the *Cynosarges* of the *Cireneans*, or the Gardens of the *Epicureans*, and the Schools of other Philosophers, with the same freedom, if he had found or judged any thing in them worthy of his knowledge; as likewise calling back all learners from their credulous superstitions, by name he admonishes them that the evidences of Authority are not so much to be sought for as the evidences of reason; because the Authority of those who teach is many times prejudiciall to those who learn, for they leave off to try any thing by their own judgment, they account that firm which they see to be so judg'd by him whom they approve of. For which cause let us compare true principles of Physick, though new, with the opinions of the Antients, for here we shall find many things disagreeing; let us try the Anatomickall exercise of *Harvey*, let us see what that will help us; nor let us longer imitate the *Sepias*; For as those who  
when



### *The Preface.*

when they find that the Fishermen are in persute of them, throwing out ink, which they have instead of blood, darkning the water, hide themselves, and do as it were stop and block up the Fishermens way; nor let us need to be so press'd and constrain'd by truth, light, firm and constant reason, for that troubled water will settle at some time, time will blot out the inventions of opinion, and confirm the judgments of truth. We have a very remarkable tryall of this in a very famous man, *Vopiscus Fortunatus Plempius*, Doctor of Physick and Arts in the Vniversity of *Lovain*, and prime practitioner there, whose opinion of *Harvey* we thought fit here to set down, which he gave in his 2 *Book* concerning the foundation of Physick, *chap. 7.* these are his words, *England* of late hath brought forth a new opinion concerning the motion of the heart, which *William Harvey* hath published in a little book purposedly set out by him; he builds his opinion upon very plausible reasons, inso-much that it is allowed by many learned men at this day, and he is call'd as by a title of honour by one of his own Countrymen, the surrounder of the little World, to distinguish him from another Englishman who first went about the greater World. This invention did not please me at first, which I did testifie both by speech and writing against it, but afterwards when I did most earnestly endeavour to refute and explode it, I was refuted and exploded my self, so much are his reasons not  
only

*The Preface.*

only perswading but forcing ; but diligently did I examine it all , and in some dogs , dissected by me for that end , found it to be very true being likewise advis'd to do this by a most famous man, *Waleus* , Professor of *Lyden* , whose candid and settled judgment I do much esteem and in this businesse am much engaged to him. Here's a great change in his judgment. Hence I begin to hope for equity in others , that laying aside all hatred , and acknowledging their error , they will at last with *Plempius* begin to think well of *Harvey*. It is a sign of a malicious and wicked mind to be delighted with error , to hate light , to follow darknesse , to calumniate the industry of good men , which fault belongs only to very filthy and vile persons ; vile we may say , not a good natured man , no tollerable or high disposition was ever tainted with this blemish. Search antient times , search ours , you shall not read , hear nor see , any other than melancholy and malignant natures , which *Saturn* has blasted with his constellation , envious to others , and distrustfull of themselves , prone and made apt to this vice. Do not you see that those little dogs which bark at guests , do not touch wild beasts such men as those are worse , being only born to wound and vex people ; born I say , for really they do so lean and encline to that vice that they are never at rest but when they disturb others. If his reprovers should say *William Harvey* has observed , and found fault with

with



### *The Preface.*

with the errors of the antients, they should indeed say true, but they should say much truer if they should add, *William Harvey* by his long and studious observation, and meditation of things in Anatomy, has propounded the means to take away all Thorns, Flints, and other impediments out of the way of Physick, that the journey of it might be plain, easie, quick, and streight, that not only the attainment to the truth and understanding of Physick, but also to the profit and fruit of it might be more easie. The wisdom of *Socrates* is known well enough by the Oracle of *Apollo*, amongst whose praises that was remarkable, and the chief, to refer the ends of liberal arts to the fruit of mans life, that men being instructed by these arts, might more easily and more readily advise concerning the transacting of businesse, and more readily execute and perform them; our *Harvey* had this end before his eyes, he open'd only the truth and fruit of the art of Physick; for he saw that there was a great gleanings left, that many things remain'd in the wide acres of Nature hitherto un-touch'd and unpassageable, into the possession of which, as to an empty place, wise men might come; but *Harvey* did not trust other mens writings, but his own faithfull eyes, the truest reporters of Anatomy, because Anatomy is better gain'd by ocular inspection than by long reading, and profound meditation. None is forc'd to swear allegiance to a Master, whom neverthelesse we likewise trust after experience. *Eupompus* a singular good Limner being asked whom of all those that went before

*The Preface.*

before him he chiefly followed, it is reported that he said, showing a multitude of men, Naturee self was to be imitated, not the Artificer. If the same *Harvey* perform'd so much, and has arriv'd so far by searching of Nature, that he, just like *Archimedes*, when he found out that the Corcor of Gold was mixt with Brasse, he cry'd aloud I have found it, I have found it. This is a true and hallowed Law of antient Philosophy, *Plato's* friend, and *Socrates* too, but Truth is more friend than they both. Wherefore let *ipse dixit* never be held here, let no excellent mans Authority be brought for an argument, let no opinion have a prerogative, but let the better bear it away. Lastly, whilst others endeavour to defend Antiquity, let us, together with *Harvey*, plead Truth and cause; Let us approve those things which are agreeable to truth, and reject those things which are contrary to it, weighing and esteeming the inventions of Antiquity not in the scale of Antiquity but in the scale of Truth: To this purpose we have again set forth *Harveys* Anatomical Exercise which in the year 1648 was set out at *Francfort* very faulty by the fault of the Printer, which the Author oft complain'd of, finding that the luminies of his reproachers had their beginning from thence, who not understanding what he said did take them ill, and endeavour'd to traduce him publickly; I say we have set it forth, and have taken a great deal of pains, that so much as was possible all things intricate, confused, or unperfected being taken away, that same exercise might come forth



*The Preface.*

forth mended and restored, in this businesse having had the help of most learned *De Back* our intimate Colleg, whose judgment we do much esteem. But that we may fold up the sails of this our Preface, let us imitate Antiquity in honoring the inventors of things. Truly, in former time the invention of Physick was so admirable, the experience of it so secret, that the authors of it were either plainly esteem'd Gods, as *Apollo* and his Son *Æsculapius*, or else they were thought worthy of Divine honour, as *Asclepiades* whom the *Illyrians* receiving as a God, did equall in honour to *Hercules*. Truly I do not approve all that Antiquity hath done, yet truly I do praise their affection and judgement, as having rightly thought, and judged, no reward sufficiently worthy to be paid to the inventors of the art of Physick. Therefore let *Harvey* be amongst us in perpetual esteem, by whose learning we have a way open to see so great a light of the art of Physick, to love and to imitate it. Let us freely attribute the modest commendation of the Son of *Syrach* concerning his own work, to *Harvey*: I watch'd last of all, as he that gleans ears after the Reapers, I have Profited through Gods Grace, I have fill'd the Winefat; Consider that I have not taken pains for my self, but for all those which love learning.

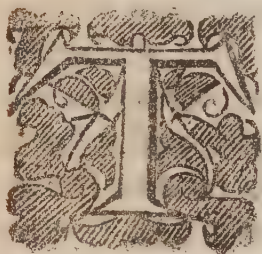
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To



To the most illustrious and invincible Monarch *CHARLS* King of Great Britain, France, and Ireland, Defender of the Faith.

Most Gracious King,



He Heart of creatures is the foundation of life, the Prince of all, the Sun of their Microcosm, on which all vegetation does depend, from whence all vigor & strength does flow. Likewise the King is the foundation of his Kingdoms, and the Sun of his Microcosm, the Heart of his Common-wealth, from whence all power and mercy proceeds. I was bold to offer to your Majesty those things which are written concerning the Heart, so much the rather, because (according to the custom of this age) all things human are according to the pattern of man, and most things in a King

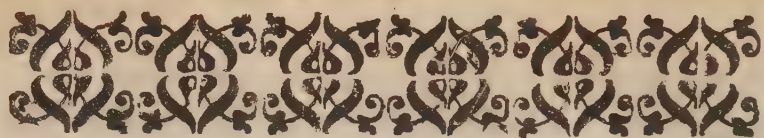
accor-



according to that of the Heart; Therefore the knowledg of his own Heart cannot be unprofitable to a King, as being a divine resemblance of his actions (So us'd they small things with great to compare,) You may at least, best of Kings, being plac'd in the top of human things, at the same time contemplate the Principle of Mans Body, and the Image of your Kingly power: I therefore most humbly intreat, most gracious King, accept, according to your accus'tom'd bounty and clemency, these new things concerning the Heart, who are the new light of this age, and indeed the whole Heart of it, a Prince abounding in vertue and grace, to whom we acknowledge our thanks to be due, for any good that England receives, or any pleasure that our life enjoys:

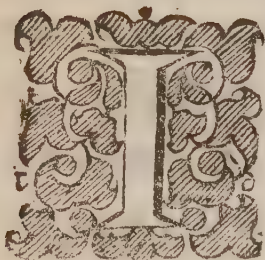
Your Sacred Majesties most  
devoted Servant,

WILLIAM HARVEY.



To the most Excellent and  
most Ornate man D. *gent*, President of the College  
of Physicians in *London*, his  
singular Friend, and the re  
of the Doctors and Physic  
ans his most loving Colo  
legs.

S. P. D.



*Did open many times before, w<sup>or</sup>*  
*Mr. Doctor, my opinion concern*  
*ing the motion and use of*  
*heart, and Circulation of*  
*blood new in my lectures;*  
*being confirm'd by ocular dem*  
*stration for nine years and more in your sight, evinc*  
*ed by reasons, and arguments, freed from the ob*  
*jections of the most learned and skilfull Anatomists,*  
*sired by some, and most earnestly required by other*  
*we have at last set it out to open view in this la*  
*Book; which, unlesse it were pass'd through y<sup>e</sup>*  
*hau*



## Dedicatory.

bands, I could hardly hope that it would come abroad entire and safe, since I can call most of you, being worthy of credit, as witnesses of those observations from which I gather truth, or confute error, who saw many of my Dissections, and in the ocular demonstrations of these things which I here assert to the senses, were us'd to stand by and assist me. And since this only Book does affirm the blood to pass forth and return through unwonted tracts, contrary to the received way, through so many ages of years insisted upon, and evidenced by innumerable, and those most famous and learned men, I was greatly afraid to suffer this little Book, otherways perfect some years ago, either to come abroad, or go beyond Sea, lest it might seem an action too full of arrogancy, if I had not first propounded it to you, confirm'd it by ocular testimony, answer'd your doubts & objections, and gotten the Presidents verdict in my favor; yet I was perswaded if I could maintain what I proposed in the presence of you & our College, having been famous by so many, and so great men, I needed so much the lesse to be afraid of others, and that only comfort, which for the love of the truth you did grant me, might likewise be hoped for from all who were Philosophers of the same nature. For true Philosophers, who are perfectly in love with truth and wisdom, never find themselves so wise, or full of wisdom, or so abundantly satisfied in their own knowledg, but that they give place to truth whensoever, or from whosoever it comes. Nor are they so narrow spirited to believe that ever any art or science was so absolutely and perfectly taught in all points, that there is nothing re-

maining

## The Epistle

maining to the industry and diligence of others, since very many professe that the greatest part of the things which we do know, is the least of the things which we know not. Neither do Philosophers suffer themselves to be addicted to the slavery of any maxims or precepts, but that they give credit to their own eyes, nor do they so swear Allegiance to Mistress Antiquity as openly to leave, or in the sight of all to desert their friend Truth. For as they think them credulous and gullible people, who at first sight do receive and believe all things, so do they take them for stupid and senselesse, that will not see things manifest to the senses, nor acknowledge the light at mid-day; and do teach as well to decline the records of the Scepticks, as the fables of the rabble, or the fables of Poets. Likewise all studious, good and honest men, do never suffer their mind so to be overwhelmed with the passions of indignation and envy, but that they will patiently hear what shall be spoken in behalf of the truth, or understand any thing which is truly demonstrated to them, nor do they think it base to change their opinion, if truth and open demonstration so perswade them, and not think it shamefull to desert their errors; though they be never so antient, seeing they very well know that all men may erre, and many things are found out by chance, which any one may learn of another, an old man of a child, or an understanding man of a fool.

But my loving Collegs, I had no desire in this Treatise to make a great volume, and to ostentate my memory, and labours, and my readings, in reherasing, crossing the works, names, and opinions of the Author



## Dedicatory.

thors and Writers of Anatomy, both because I do not professe to learn and teach Anatomy from the axioms of Philosophers, but from Dissections, and from the fabrick of Nature. As likewise that I do not endeavour, nor think it fit, to defraud any of the anti-ents of the honour due to them, nor provoke any of the moderns; nor do I think it seemly to contest and strive with those that have been excellent in Anatomy, and were my teachers. Moreover I would not willingly lay an aspersion of falshood upon any that is desirous of the truth, nor blemish any man by accusing him of an error; but I follow the truth only, and have bestowed both my pains and charges to that purpose, that I might bring forth something which might be both acceptable to good men, agreeable to learned men, and profitable to literature. Farewell most excellent Doctors, and favour your Anatomist,

WILLIAM HARVEY.



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blood is confirm'd by those things which appear in  
the heart, and which are clear from Dissections in  
Anatomy. p.93.



## The PROEME.

*By which is Demonstrated, that those things which  
are already written concerning the motion and  
use of the heart and arteries are not firm.*



I will be worth our while, seeing we are thinking of the motion, pulse, use, action, and utility of the *heart and arteries*, first to unfold such things as have been published by others; to take notice of those things which have been commonly spoken and taught, that those things which have been rightly spoken may be confirmed, and those which are false both by Anatomical dissection, manifold experience, and diligent and accurate observation, may be mended.

Almost all Anatomists, Physicians, and Philosophers to this day, do affirm with *Galen*, that the use of Pulsation is the same with that of Respiration, and that they differ only in one thing, that one flows from the Animal faculty, and the other from the Vital, being alike in all other things, either as touching their utility, or manner of motion. Whence they affirm, (as *Hieronym. ab Aq. p.* in his Book of Respiration, which he has newly set out) Because that the pulse of the *heart and arteries* is not sufficient to fan, and refrigerate, that the *lungs* were made about the *heart*. Hence it appears, that  
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*The Proeme.*

whatsoever those in former times did say concerning the *Systole* and the *Diaстole*, concerning the motion of the *heart* and *arteries*, they spoke it in relation to the *lungs*.

But since the motion and constitution of the *heart* is different from that of the *lungs*, and the motion of the *arteries* different from that of the breast, it is probable that divers uses and utilities should follow, and that the pulse of the *heart*, and the use of it, as likewise that of the *arteries*, should differ much from the pulse and use of the breast and *lungs*. For if pulse and respiration doe serve for the same use, and that the *arteries* do receive the air into their concavities in the *Diaстole*, as they commonly say, and that in their *Systole* they send out fumes through the pores of the flesh and skin; as likewise that in the space betwixt the *Systole* and *Diaстole* they do contain air; and that every time they do either expell Air, or Spirits, or Fumes; what will they then answer to *Galen*? who wrote a Book, that blood was naturally contain'd in the *arteries*, and nothing but blood, that there is neither Spirits, nor Air, as from Reasons and Experiments in the same Book we may easily gather. And if in the *Diaстole* the *arteries* are fill'd with air which they take in, and that in a greater pulse there enters a greater quantitie of air; it will follow, that whilst there is a great pulse if you dip your whole body into a bath of Water or Oyl, that the pulse shall either be lessen'd, or much slower since it is a hard thing for the air to passe through the body of the bath which encompasses them, and

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get into the *arteries*, if not altogether impossible. Likewise since all the *arteries*, aswell those which lye deeper, as those which are next to the skin, are distended with the same swiftnesse, how can the air so freely, so swiftly, passe through the skin, flesh, & habit of the whole body, into the depth, as it can through the skin alone? And how shall the *arteries* of *Embryons* draw the air into their concavities through their mothers belly, and the body of the womb? And how shall Whales, Dolphins, and great Fishes, and all sorts of Fishes in the bottom of the Sea, take in the air, by the swift pulse in the *Systole* and *Diastole* of their *arteries*, through such a great masse of water? But to say that they suck up the air implanted in the water, and doe return their fumes into it, is not unlike a fiction. And if in the *Systole* the *arteries* doe expell their fumes out of their concavities through the pores of the flesh and skin, why not the Spirits likewise, which they say are contain'd there too, since Spirits are much thinner than fumes? And if the *arteries* do receive the air both in the *Systole* and the *Diastole*, and return it, as the *lungs* do in respiration, why doe not they do this in inflicting of a wound when an *arterie* is cut? In the cutting of the wind pipe by a wound it is clear, that the air does enter and return by two contrary motions. But it is clear in the section of an *arterie*, that the air is thrust out with one continuall motion, and the air does not enter and return. If the pulse of the *arteries* doe refrigerate the parts of the body, and cool it, as the *lungs* doe the *heart* it self, how do they say that the *arteries* do carry the blood



*The Proeme.*

blood very full of vitall Spirits into all the parts which do nourish the heat of the parts, wake it when it is asleep, and recruit it being spent? and how comes it to passe, that if you tye the *arteries*, the parts are not onely numm'd, cold, and look pale, but at last leave off to be nourished? which happens, according to *Galen*, because they are also depriv'd of that heat, which did flow from above out of the *heart*: Since it is clear from hence, that the *arteries* do rather carry heat to the parts, than cooling or refrigeration. Besides, how shall the *Diastole*, both draw Spirits from the *heart* to warm the parts, and likewise draw cold from outwards? Further, although some affirm, that the *lungs*, *arteries*, and *heart* do serve for one and the same purpose; Yet they say that the *heart* is the storehouse of the Spirits, and likewise that the *arteries* do contain spirits and send them abroad; but contrarie to the opinion of *Columbus*, they do deny that the *lungs* do make any Spirits or retain them. But likewise these men affirm with *Galen* against *Erasistratus* that blood is contain'd in the *arteries*, and not Spirits. These opinions seem to quarrel with one another, and to refute each the other, insomuch that all are not undeservedly suspected. It is manifest that the blood is contain'd in the *arteries*, and that the *arteries* alone do carry out the blood, both by the experiment of *Galen* as likewise by the cutting of an *arterie* in wounds (which *Galen* in his book, that blood is contain'd in the *arteries* affirms, and in very many places) that by a great and forcible profusion the whole  
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*The Poeme.*

masse of blood will be exhausted in the space of ha  
an hour. The experiment of *Galen* is thus, bin  
the *Arterie* at both ends with a little cord, and cut  
ting it up in length, in the middle you shall find  
in that place which is comprehended betwix  
the two ligatures, nothing but blood, and so does he  
prove that it contains only blood. Whence we may  
argue likewise in the same manner; If you find  
the same blood in the *arteries* which is in the *veins*,  
being bound and cut up after the same manner, as  
I have often tryed in dead men, and in other crea-  
tures, by the same reason we may likewise conclude  
that the *arteries* do contain the same blood which  
the *veins*; and nothing but the same blood. Some  
whilst they endeavour to dissolve this difficulty,  
affirming that it is *Arterial blood* and full of Spirit,  
they do silently graunt that it is the function of the  
*arteries* to carry the blood from the *heart* into the  
whole body, and that the *arteries* are full of blood.  
(For the blood that has Spirit is no lesse blood.)  
Likewise no man does deny that the blood, as it is  
blood, and flowes in the *veins*, is imbued with  
Spirits. Albeit the blood in the *arteries* do swell  
with greater store of Spirits, yet those Spirits are  
to be thought inseparable from the blood, as those  
which are in the *veins*; and that Blood and Spirit  
make one body, as whey and butter in milk, or  
heat and water in warm water, by which the *arte-  
ries* are fill'd, and the distribution of which body  
from the *heart* the *arteries* do perform, and this bo-  
dy is nothing else but blood. But if they say that  
his blood is attracted out of the *heart* into the *arte-  
ries*



### *The Proeme.*

*teries* by the *Diaſtole* of the *arteries*, then they ſeem to preſuppoſe that the *arteries* by their own diſtenſion, are fill'd with that blood, and not with the ambient air as before; but if in the *Diaſtole*, they ſhall together receive the blood, the air, the heat, & the cold at one time, that is improbable. Further, when they do affirm that the *Diaſtole* of the *heart* and *arteries* is at one time, and ſo their *Syſtole*, one of theſe two will be inconfiſtent. For how ſhall two bodies ſo nearly joyn'd together, whiſt they are diſtended, one of them draw from the other, or when they are contracted at one time, how ſhall one receive any thing frō tother? Over and above, it may be perchance impoſſible, that any body ſhould ſo attract into it ſelf, as that it ſhould be diſtended, ſeeing to be diſtended is to ſuffer, unleſſe it do it as a ſponge returning to its own natural conſtitution after external conſtriction. It were a hard thing to feign that any ſuch thing could be in the *arteries*. But I believe I can eaſily demonſtrate, and have heretofore demonſtrated, that the *arteries* are diſtended, becauſe they are fill'd like Sachells or baggs, not becauſe they are blown up like bladders. Yet notwithstanding *Galens* experiment, in his book, that blood is contain'd in the *arteries*, is otherwiſe, after this manner. He did cut the *arterie* being laid open in length, and into the wound he thruſt a reed or a hollow pipe and ſtop'd the wound that the blood could not leap out. So long (ſays he) as the *arterie* is thus all of it will bear, but ſo ſoon as with a thred you have above the *arteries* and pipe contracted the tunicle of the *arterie* with

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a noose, and stop'd it with heed, you shall not see the arterie beat any more above the noose. I have neither tryed this experiment of *Galens*, nor do I thinke it can be tryed and the body kept alive, by reason of the preruption of the blood out of the arterie; nor can the pipe close the wound without a *ligature*; nor do I doubt but that the blood will stream further through the concavity of the pipe. Nevertheless *Galen* by this experiment seems to prove that the pulsifick faculty flows through the *tunicles* of the *arteries* from the heart, and that the *arteries* whilst they are distended by the pulsifick faculty are fill'd, because they are distended as bellows, not distended because they are fill'd like baggs. But the contrary is manifest, both in cutting of an *arterie*, and in wounds: For the blood is poured out of the *arteries* with a forcible leaping, sometimes farther, sometimes nigher, leaping by fits, but the leaping of it is always in the *Diastole* of the *arterie*, not in the *Systole*. By which it appears clearly that the *arterie* is distended by the impulsion of blood. For of it self it cannot by its distention throw the blood out so far, it should rather attract air into it through the wound, according to those things which are commonly spoken. Nor let the thicknesse of the *arterial tunicles* cosen us in that, that the pulsifick faculty flows from the heart by the *tunicles* themselves; for in some creatures *arteries* doe differ nothing from *veins*, and in the most remote parts of a man, and the disseminations of the *arteries*, as in the brain, hand, &c. no body can distinguish an *arterie* from a *vein*, for they have both



*The Proeme.*

both the same *tunics*. Besides in an *Aneurism*, which is begot by the arroasion or incision of an *arterie* it has the same pulsation with an *arterie*, and yet it has not the *tunicle* of an *arterie*. Most learned *Riolan* doth witness this with me in his seventh book. Nor let any man beleeeve, that the use of pulse and respiration is one and the same, because that the pulses are greater, more frequent, and swifter, for the same causes as respiration is, to wit with running, anger, bathing or any other thing which heats. For not only that experiment is false (which *Galen* endeavours to convince) that by immoderate repletion the pulses are greater, & breathing lesser; but likewise in boy, pulses are frequent, and respiration the while very seldom. Likewise in fear, care, and anxiety of the mind, as also too in some feavers the pulses are swift and frequent, and respirations more seldome. These and the like inconveniences do follow upō the opinions which are set down concerning the pulse and use of the *arteries*. Likewise those things which are affirmed concerning the pulse and use of the *heart* are no lesse entangled with very many and inextricable difficulties. They do commonly affirm that the *heart* is the store-house and fountain of vital Spirit, by which it gives life to all the parts, and yet they deny that the *right ventricle* makes Spirits, but only gives nourishment to the *lungs*; from whence say they fishes have no *right ventricle* of the *heart*, and indeed in those which have no *lungs* it is wanting, and that the *right ventricle* of the *heart* was meerly made for the *lungs* sake.

1. Why I beseech you? since the constitution of both

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both the *ventricles* is alike, their *fibers* fram'd alike and so of their *tendons*, *Portals*, *vessels*, *ears*, and both of them are found full of blood in dissection alike blackish, alike knottie: why I say should we think that they were appointed to such different uses, seeing action, motion, pulse, is the same in both? If the three three-pointed *portals* in the entrie of the right *ventricle*, be a hinderance on the return of the blood into the *vena cava*, and if those three semilunarie *portals* in the orifice of the *arteriosa vena* were made to hinder the regresse of the blood; since they are so likewise in the *left ventricle*, shall we deny that they were likewise made to hinder the egress and regresse of the blood there?

2. And since they are almost altogether after the same manner, both in their form and position in the *left* as in the *right*, why do they say that here they hinder the egress and regresse of the Spirits, and in the right hinder the egress and regresse of the blood? this same *organ* does not seem to be fit to hinder the motion of the blood and Spirits alike.

3. And how is it probable, as *Realdus Columbus* does observe, that there needs so much blood to the nutrition of the *lungs*, since this vessel, that is to say the *vena arteriosa*, is bigger than both the branches of the distributives descending into the *crural vein*?

4. And I beseech you since the *lungs* are so near, and the vessel is so great, and they in continual motion, what needs the motion of the *right ventricle*, and what is the matter that nature for the nourishing of the *lungs* was forc'd to joyn another *ventricle* to the *heart*?



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When they say that the *left ventricle* draws matter out of the *lungs*, and the right bosome of the *heart*, to make Spirits, that is to say air and blood, and does likewise distribute the spirituous blood into the *aorta*, and that fumes are sent back by the *Venal arterie* into the *lungs*, and the Spirits into the *aorta*, what is it that makes the separation, or how comes it to passe, that spirits and fumes passe sometimes hither sometimes thither without permission and confusion? if the three pointed mitre-fashioned *portals* hinder not the return of fumes into the *lungs*, how shall they hinder the return of air? And how shall the half-moon *portals* hinder the regresse of the spirits from the *aorta*, the *Diastole* of the *heart* pursuing? and by what manner of way do they say that the spirituous blood is distributed through the *venal arterie* into the *lungs* out of the *left ventricle*, and that the three-pointed doors do not hinder? seeing they affirm that the air does enter through the same vessel out of the *lungs* into the *left ventricle*, to the regresse of which they would have these three-pointed doores to be a hinderance. Good God how shall the three-pointed doors hinder the regresse of air and not of blood? Further they having destined the *vena arteriosa* being a large vessel, made with the *tunicle* of an *arterie*, for one only and a private use, that is to say to nourish the *lungs*, Why do they affirm that the *Venal arterie* being scarce so big, having the *tunicle* of a *vein* soft and loose, to be made for more uses, to wit three or four? For they will have the air passe through it, out of the *lungs* into the *left ventricle*, and they will have

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the fumes likewise to return through it out of the heart into the *lungs*, they will have a part of the spirituous blood to be distributed by it, for the refreshing of them: They will have these to send fumes from the heart, and the other to send air to the heart by the same pipe, when notwithstanding nature did not use to frame one vessel, and one way, for such contrary motions and uses, nor is it ever seen to be so.

If they do affirm that fumes and air do goe and return by this way, as through the transpirations or *Bronchia* of the liver, why cutting up the *arteria venosa* can we find neither air nor fumes? And whence is it that we see that *arteria venosa* always full of thick blood, and never full of air, since we see air remaining in the *lungs*?

If any would try the experiment of *Galen*, and cut the windpipe of a dog being yet alive, and forcibly fill the *lungs* with air, and being filled bind them streight, afterwards cutting up his breast he shall find great store of air in the *lungs*, even to their utmost *tunicle*, but nothing in the *arteria venosa*, nor in the *left ventricle* of the heart. But if in a living dog either the heart did attract it, or the *lungs* did pulse it through, they should do it much more in this experiment. Yea in the administration of Anatomie blowing up the *lungs* of a dead body, who doubts but the air would enter this way, if there were any passage? But they do so much esteem the use of this *arteria venosa* for the conveying of air from the *lungs* to the heart, That *Hier. Fabr. ab aq. pend.* does assert, that the *lungs* were made for this vessels sake, and that it is the chiefest part of the *lungs*.



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But I beseech you, if the *Arteria venosa* had been made for the conveying of air, why has it the constitution of a *vein*?

Nature would stand more in need of pipes, and of annular ones, indeed such as the *Bronchia* are, that should be alwayes open, and never lie flat, that they might be altogether voyd of blood, lest the wetnesse should hinder the passage of the air, as it is manifest, (when the *Lungs* are diseas'd by the stuffing or least entrie of slegm into the *Bronchia*) when we make a whistling or a noise in our breathing.

That opinion is lesse tolerable, which (supposing that an ayrie and bloody matter is necessary for the making of vital Spirits) does assert, that the blood is drawn through the hidden pores of the *mediastin* of the *heart*, out of the *right ventricle* into the *left*, and that the air is drawn through a great vessel, the *arteria venosa*, out of the *Lungs*; and for that cause, that there are more pores in the *septum* of the *heart*, fitter for the production of the blood. But by my troth there are no such pores, nor can they be demonstrated.

For the substance of the *septū* of the *heart* is thicker, & more compact than any part of the body, except the *bones* and *nerves*. But if there were holes, how were it possible, (since both the *ventricles* are distended at one time) that the one can draw any thing from the other, or that the *left* can draw blood from the *right*? And why should not I rather beleieve that the *right* draws Spirits from the *left*, than that the *left* through the same holes should draw blood from the *right*? But it is truly  
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wonderfull and incoherent, that at the same instant the blood should be most conveniently drawn through hidden and obscure passages, and again through very open ones. And why, I beseech you, have they their refuge to hidden, invisible, uncertain, and obscure pores for the passage of the blood into the *left ventricle*, when there is such an open way through the *arteria venosa*? Truly it is a wonder to me, that they would rather invent or make a way through the *septum* of the *heart*, which is grosse, thick, hard, and most compact, than through the patent *Vas Venosum*, or else through the substance of the *lungs*, thin, loose, most soft and spongius. Besides, if the blood could passe thorough the substance of the *septum*, or be imbibed by the *ventricles*, what need were there of the branches of the *Coronal arterie* divided for that purpose? Which is very worthy to be observ'd, in a Birth (when all things are thinner and softer) Nature was forced to bring the blood through an oval hole, out of the *Vena Cava* through the *Arteria Venosa*, how can it be possible that she should passe it so conveniently, and with no trouble, through the *septum* of the *heart*, being now made thicker after growth?

*Andreas Laurentius* in his *Lib. 9. Chap. 11. Quest. 12.* being back'd with the authority of *Galen*, and the experience of *Hollerius*, affirms, that whey, and the attar, out of the cavitie of the brest, being supp'd up by the *arteria venosa*, can be expelled through the *left ventricle* of the *heart* and the *arteries*, together with the *Vrine* and the *Excrements*; As likewise for the confirmation of it he re-

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### *The Proeme.*

ates the case of a certain Melancholy man, who was freed from a Paroxysm by the emission of troubled, stinking, tart *urine*, by which kind of disease at last dying, and dissecting the body, no such substance as he piss'd, did either appear in the *bladder* or in the *reins*, any where, but a great deal in the *left ventricle* of the *heart*, and concavity of the breast, whence he vaunts that he foretold the cause of such diseases. But I cannot chuse but wonder, since he had guess'd and foretold that Heterogeneous matter could be evacuated by the same passage, that he either could not or would not see or affirm, that through the same wayes the blood could be conveniently, according to Nature, brought out of the *lungs* into the *left ventricle*.

Therefore from these, and many such things as these, it is clear, that those things which are before spoken by former Authors, concerning the motion and use of the *heart* and the *arteries*, do either seem inconvenient or obscure, or admit of no possibility, if one do diligently consider them; therefore it will be profitable to search more deeply into the businesse, and to contemplate the motions of the *arteries* and *heart*, not only in man, but also in all other creatures that have a *heart*; as likewise by the frequent dissection of living things, and by much ocular testimony to discern and search the truth.







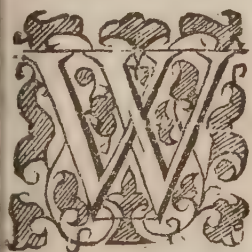
# ANATOMICAL EXERCISES,

CONCERNING

The motion of the *Heart*,  
and *Blood*, in Living Creatures.

## CHAP. I.

*The Causes which mov'd the Author to  
Write.*



When first I applyed my  
mind, to observation, from  
the many dissections of  
Living Creatures as they  
came to hand, that by  
that meanes I might find

out the use of the motion of the *Heart*  
and things conducive in Creatures; I  
straightwayes found it a thing hard to be  
attained, and full of difficultie, so with *Fra-*  
*castorius* I did almost beleieve, that the mo-  
tion of the Heart was known to God al-  
one: For neither could I rightly distin-

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guish, which way the *Diastole* and *Systole* came to be, nor when nor where the *dilatation* and *constriction* had its existence. And that by reason of the quicknesse of the motion, which in some creatures appeared in the twinckling of an eye, like the passing of Lightning; so that sometimes the *Systole* did present it self to me from this place: *Contraction.* and the *Diastole* from that place, sometimes *Expansion.* just contrary, sometimes the motion was various, sometimes confus'd: whence I was much troubled in mind, nor did I know what to resolve upon my self, or what beleeft to give to others, nor wonder'd I at that which *Andreas Laurentius* writes. That the motion of the heart, was as the ebbing and flowing of *Euripus* to *Aristotle*. At last using daily more search and diligence, by often looking into many and severall sorts of creatures, I did beleeve I had hit the nail on the head, unwinded and freed my self from this Labyrinth, and thought I had gain'd both the motion and use of the *heart*, together with that of the *arteries*, which I did so much desire: Since which time I have not been afraid, both privately to my friends, and publickly in my Anatomie Lectures to deliver my opinion.

Which, as it commonly falls out, pleased some, and displeased others; Some there were that did check me, spoke harshly, and  
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found fault that I had departed from the precepts and belief of all *Anatomists*; Others avouching that it was a thing new, worthy of their knowledge, and exceeding profitable, requir'd it to be more plainly delivered to them. At last, mov'd partly by the requests of my friends, that all men might be partakers of my endeavours, and partly by the malice of some, who being displeas'd with what I said, and not understanding it aright, endeavoured to traduce me publickly, I was forced to recommend these things to the Press, that every man might of me, and of the thing it self, deliver his judgement freely. But so much the more willing I was to it, because *Hieronym.* *lib Aq. P.* having learnedly and accurately set down in a particular Treatise, almost all the parts of living creatures, left the *Heart* only untouched. Lastly, if any profit or advantage might by my industry in this accrew to the republick of Literature, it might perchance be granted that I had done well, and others might beleieve that I had not spent my time altogether to no purpose, and as the oldman says in the *Comedie*,

*No man so well e'r laid his count to live,  
But that things, age, and use, some new thing give,  
That what you thought you knew, you shall not know,  
And what you once thought best, you shall forgoe.*

This may perchance fall out now in the

motion of the *heart*, that from hence the way being thus pervious, others trusting to more pregnant wits, may take occasion to doe better, and search further.

## CH A P. II.

*What manner of motion the Heart has in the dissection of living Creatures.*

**F**irst then in the *hearts* of all creatures being dissected whilst they are yet alive opening the *breast*; and cutting up the *capsule*, which immediately environeth the *heart*, you may observe that the *heart* moves sometimes, sometimes rests: and that there is a time when it moves, and when it moves not.

This is more evident in the *hearts* of colder creatures, as the *Toads*, *Serpents*, *Frogs*, *House-Snails*, *Shrimps*, *Crevises*, and a manner of little *Fishes*. For it shews it self more manifestly in the *hearts* of hotter bodies, as of *Dogs*, *Swine*, if you observe attentively till the *heart* begin to dye, and move faintly, and life is as it were departing from it. Then you may clearly and plainly see that the motions of it are more slow and seldome, and the restings of it of a longer continuance: and you may observe and distinguish more easily, what manner of

motion



motion it is, and which wayes it is made, in the resting of it, as likewise in death, the *heart* is yeelding, flagging weak, and lyes as it were drooping.

At the motion, and whilst it is moving, three things are chiefly to be observed.

1. That the *heart* is erected, and that it raises it self upwards into a point, insomuch that it beats the breast at that time, so as the pulsation is felt outwardly.

2. That there is a *contraction* of it every way, especially of the *sides* of it, so that it appears lesser, longer, and contracted. The *heart* of an *Eel*, taken out, and laid upon a trencher, or upon ones hand, doth evidence this: It appears likewise in the *hearts* of little *Fishes*, and of those colder *Animals* whose hearts are *sharp at top, and long*.

3. That the *heart* being grasp'd in ones hand whilst it is in motion, feels harder. This hardnesse arises from *tention*, like as if one take hold of the *tendons* of ones arm by the *Elbow* whilst they are moving the fingers, shall feel them bent and more resisting.

4. Tis moreover to be observed in *Fish*, and colder *Animals* which have blood, as *Serpents*, *Froggs*, at that time when the *heart* moves it becomes whitish, when it leaveth motion it appears full of sanguine colour. From hence it seemed to me, that the motion of the *heart* was a kind of *tenti-*

on in every part of it, according to the drawing and constriction of the *Fibers* every way; because it appear'd that in all its motions, it was erected, received vigour, grew lesser, and harder, and that the motion of it was like that of the *muscles*, where the contraction is made according to the drawing of the *nervous parts*, and *fibers*, for the *muscles* whilst they are in motion, and in action, are invigorated, and stretched, and soft become hard, they are uplifted, and thickned, so likewise the *heart*.

From which observations with good reason we may gather that the *heart* at that time whilst it is in motion, suffers constriction, and is thickned in its outside, and so streightned in its *ventricles*, thrusting forth the blood contained within it, which from the fourth observation is evident because that in the *tension* it becomes white, having thrust out the blood contained within it, and presently after in it relaxation, and rest, a purple and crimson colour returns to the *heart*. But of this no man needs to make any further scruple since upon the inflicting of a wound into the *cavities* of the *ventricle*, upon every motion, and pulsation of the *heart*, in the very *tension*, you shall see the blood within contained to leap out.

So then these things happen at one & the same time, the *tension* of the *heart*, the *con-*



Elion of the point, the beating (which is felt outwardly) by reason of its hitting against the *breast*, the incrassation of the sides of it, and the forcible protrusion of the blood by constriction of the *ventricles*.

Hence the contrary of the commonly received opinion appears, which is, that the *heart* at that time when it beats against the *breast*, and the pulsation is outwardly felt, it is beleev'd that the *ventricles* of the *heart* are dilated, and replete with blood, though you shall understand that it is otherwise, and that when the *heart* is contracted it is emptied. For that motion which is commonly thought the *Diastole* of the *heart*, is really the *Systole*, and so the proper motion of the *heart* is not a *Diastole* but a *Systole*, for the *heart* receives no vigour in the *Diastole*, but in the *Systole*, for then it is extended, moveth, and receiveth vigour.

Neither is that to be allowed, though it is confirmed by a comparison alleged by the *Divine Vessalus*, of a wreath of *Oziers*, meaning of many twiggs joynd together in fashion of a *Pyramide*: that the *heart* doth only move by the streight *fibers*, and so whilst the top is brought near to the bottom, the sides of it are dilated round about, and do acquire the form of a little *gourd*, and so take in blood (for according to all the drawing of the *Fibers* which it

has, the *heart* is stiffned, and gatherd together ) But that the outside and substance of it are rather thickned and dilated, and that whilst the *Fibers* are stretched from the top of the *corner* to the bottom, the sides of the *heart* do not encline to an orbicular figure, but rather contrary, as every *Fiber* circular lies plac'd, does in its contraction encline to streightness, and as all the *Fibers* of the *muscles* whilst they are contracted and shortned of their length, so towards the sides they are extended, and are thickned after the same fashion as the bodies of the *Muscles*.

To this add, that not only in the motion of the *heart*, by erection and incrassation of the sides of it, it so falls out, that the *ventricles* are streightned, but moreover all the sides inwardly are girt together as it were with a *noose*, for expelling the blood with greater force, by reason that those *Fibers* or little *tendons*, amongst which there are none but streight ones, ( for those in the outside are circular ) called by *Aristotle Nerves*, are various in the *ventricles* of the *hearts* of greater creatures, whilst they are contracted together with a most admirable frame.

Neither is it true which is commonly believ'd, that the *heart* by any motion or distention of its own doth draw blood into the *ventricles*, but that whilst it is moved



red and bended, the blood is thrust forth; and when it is relax'd and falls, the blood is received in manner as follows.

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C H A P. III.

*What manner of motion the Arteries have in dissection of living creatures.*

**T**Heir occurs in the motion of the heart these things further to be observ'd, which have relation to the moving and pulsation of the *arteries*.

1. That whilst there is a tention, contraction of the *heart*, and a percussion of the *breast*, and an apparent *Systole*, the *arteries* are dilated, do beat, and are in their *Diastole*. In like manner when the right *ventricle* thrusts out the blood contained in it, the *arterious vein* beates and is dilated, together with the rest of the *arteries* of the body.

2. When the left *ventricle* ceaseth to move, beat, and to be contracted, the beating of the *arteries* ceases: nay when the *tention* is but faint, the pulsation of the *arteries* is hardly to be perceived, and so likewise in the *arteriall vein*, when the right ceases.

3. Likewise cutting or piercing any *arterie* in the very *tention* of the left *ventricle* the

the blood is forcibly thrust out of the wound, so cutting the *arteriall vein* at the same time, and in the *tention* and contraction of the *right ventricle*, you shall see the blood to burst out forcibly from thence.

So likewise in *Fishes*, cutting the *conduite pipe*, which leads from the *heart* to the *gills* at which time you shall see the *heart* stiff and contracted, from thence you shall likewise see the blood forcibly thrust out.

Lastly, as in the cutting of any *arterie* the blood leaps out sometimes farther sometimes nearer, you shall find the out-leaping to be just with the *Arterial Diastole*, at which time the *heart* strikes the *breast* and at that time then when it appears that the *heart* is in its *tention*, and contraction, it is in its *Systole*, and that the blood is thrust out with the same motion.

From hence, it is against the Common rule appears to be clear, that the *Arterial Diastole* is at the same time with the *Systole* of the *heart*, and that the *arteries* are fill'd and distended, by reason of the immission and intrusion of blood made by the contraction of the *ventricles* of the *heart*; as likewise that the *arteries* are stretched, because they are fill'd like *Baggs* or *Sachels*, and are not fill'd because they are blown up like *Bellows*: and for the same cause do all the *arteries* of the body beat, by reason of



of the tention of the left ventricle of the heart, as the arteriall vein from the tention of the right.

Lastly, That the pulsation of the arteries arises from the impulsion of blood from the left ventricle; just so, as when one blows into a glove, he shall see all the fingers swell up together, and assimilate this pulsation. As also according to the tention of the heart, the pulsations are greater, more vehement, more frequent, swifter; keeping the number, quantity, and order, of the beating of the heart.

Nor is it to be expected, that because of the motion of the blood there should be a certain distance of time betwixt the constriction of the heart, and the dilatation of the arteries (especially of those that are furthest distant) that they be not at the same instant, because that in a *bason* (as likewise in a Drum, and long peeces of Timber) the stroke and the motion are alike soon at both extremes: since the case here is just as in the blowing up of a glove, or a Bladder. Hence *Arist. 3. Anim. C. 9. de resp. Cap. 15.* The blood (says he) of all living creatures, beats within their veins, (meaning the arteries,) and with a continuall motion moves every where: so do all the veins beat together, and by turns, because they have their dependance upon the heart. But it does always move, wherefore they like-

*'Anatomicall Exercises.'*

*likewise move, and in order to its motion when it doth move.*

We must observe with *Galen*, that the *arteries* were named *veins* by the antient Philosophers. I chanced on a time to see and have in hand, an accident which did most plainly confirm this to me to be true. A certaine person had a great swelling which did beat on the *right side* of his *throat* neerer to the descent of the *subclavial arteries*, into the *armpits*, call'd *Aneurisma*, begotten by the corrosion of the *arterie* it self, which grew bigger and bigger every day, being filled with the immission of blood from the *arterie* at every *pulsation*; which was found upon the cutting up of his body after he was dead. In this man the *pulse* of his *arm* upon that side, was very weak, by reason that the greater portion and influx of blood was turned into the swelling, and so diverted.

Wherefore, whether it be by compression, stuffing, or interception, that the motion of the blood through the *arteries* be hindered, in that case the furthestmost *arteries* doe beat lesse, seeing the pulse of the *arteries* is nothing but the impulsion of the blood into the *arteries*.



## C H A P. IV:

What manner of motion the Heart, and the ears of it, have in living Creatures.

BESIDES these, there are to be observed such things as belong to the ears, which *Faspar Bauhinus P. C. Anat. 22. 21.* and *Johan. Riolaunus*, men very learned, and skillfull Anatomists have observed, and advises, that (if in the live dissection of any animals you have good regard to the motion of the heart, you shall see four motions, distinct both in time and place: with leave of such eminent men be it spoken, there are four motions distinct in place, but not in time; for both the ears move together, and both the ventricles move together, so that there are four motions distinct in place, only at two times, and it is thus,

There are as it were at one time two motions, one of the ears, and another of the ventricles themselves, for they are not just at one instant, but the motion of the ears goes before, and the motion of the heart follows; and the motion seemes to begin at the ears, and to passe forward to the ventricles; when all things are already in a languishing condition, (the heart dying away, as it is both in *Fishes*, and other colder animals which have blood) there  
inter-

intercedes some short resting time betwix these two motions, and the *heart* being it were weakned, seems to answer the motion, sometimes swifter, sometimes slower; last of all drawing towards death, ceases to answer by its motion, and only by nodding its head seems as it were to give consent, and moves so insensibly, that it seems only to give a signe of motion to the *ears*: So the *heart* first leaves beating, before the *ears*, so that the *ears* are said to out-live it: the *left ventricle* leaves beating first of all, then its *ear*, then the *right ventricle*, last of all (which *Galen* observes) all the rest giving off and dying, the *right ear* beats still: so that life seems to remain last of all in the right. And whilst by little and little the *heart* is dying, you may see after two or three beatings of the *ear* the *heart* will, being as it were rowled, answer, and very slowly and hardly endeavour and frame a motion.

But this is chiefly to be observed, that after the *heart* has left beating, and the *ears* are beating still, putting your finger upon the *ventricle* of the *heart*, every pulsation is perceived in the *ventricles*, just after the same manner as wee said the pulsations of the *ventricles* were felt in the *Arteries* a distention being made by impulsion of blood: and at this time, the *ears* only beating, if you cut away the  
point



xt of the *heart* with a pair of *Scissors*, you shall see the blood flow from thence at every pulsation of the *ear*, so that from thence appears which way the blood comes into the *ventricles*, not by attraction or distension of the *heart*, but sent in by the impulsion of the *ears*.

It is to be observed, that all those which call pulsations, both in the *ears*, and in the *heart*, are contractions, and that the *ears* are evidently first contracted, and afterwards the *heart* it self. For the *ears* whilst they move and beat, become whitish, especially when there is little blood in them, for they are fill'd as the *cellars* and *treasuries* of blood, by the compressive motion of the *veins*, and the tending of the blood to its proper *Centre*. Nay further, it is most evident, in the *ends* and *extremities* of them, that the whiteness arises meerly from the contraction of them.

In *Fishes*, and *Froggs*, and the like, having but one *ventricle* of the *heart* (for in lieu of one ear they have a little bladder plac'd at the bottom of their *heart* full of blood) you shall most evidently see the bladder first contracted, and the contraction of the *heart* to ensue.

Notwithstanding I thought fit to insert those things which were of a contrary course, the *heart* of an *Eel*, as also of some *Fishes*, and living creatures being tane out beats

beats without *ears*, nay though you cut in pieces, you shall see the pieces when they are asunder contract and dilate themselves so that in such, after the motion of the *ears*, the *heart* does leap and beat : But this pertinance is only proper to such creatures, which are more tenacious of life, whose *radical moisture* is more glutinous fatter, tougher and not so easie to be dissolv'd. This also does appear in the flesh of *Eels*, which after the skinning, exenteration, and cutting in pieces, retains motion.

This is certain that upon a time trying an experiment upon a *dove*, after that the *heart* had quite left motion, and that the *ears* had a while given over, I wetted my finger with spittle, and being warmed kept it a while upon the *heart*, by this fomentation, as if it had received strength and life afresh, the *heart*, and its *ears* began to move, to contract, and open, and did seem as it were recall'd back again from death.

But besides all these I have often observ'd that after the *heart* it self, and even its right *ear*, had at the very point of death left off beating, there manifestly remain'd in the very blood which is in the *right ear*, an obscure motion, and a kind of inundation, and beating, that is to say, so long as it seem'd to be possess'd with any blood or spirit.

A thing of the like nature, in the first  
gene-



generation of a living creature most evidently appears in a hens egg within seven days after her sitting, first of all there is in it a drop of blood, which moves, as *Aristotle* likewise observ'd, which receiving increase, and the *Chicken* being form'd in part, the *ears* of the *heart* are fashioned, which beating there is always life; then afterwards within a few days the body beginning to receive its lineaments, then likewise is the body of the *heart* framed, but for some days it appears whitish and without blood, nor doth it beat and move as the rest of the body; as also I have seen in a child after three moneths, the *heart* to be also form'd, but whitish, and without blood; in the *ears* of which notwithstanding there was great store of blood, and of a crimson colour: so likewise in the egg when the *Chick* was new form'd, and encreased, the *heart* began likewise to encrease, and to have *ventricles* in which it began to receive blood and pass it through.

So that if a man will more narrowly pry into the truth, he will not say, that the *heart* is the first thing that lives, and last that dies, but rather the *ears* (and in *Snakes*, *Fishes*, and such like creatures, the part which is instead thereof) and that it both lives before the *heart*, and dies after it.

Nay its doubtful too, whether or no before them also the spirit and blood have an ob-

scure beating, which to me it seem'd it retain after death, or whether we may say that with this beating the life begins, seeing the Sperm, and prolific Spirit, common to all living creatures, goes from them with a kind of leaping, as if it self were a living creature, So Nature in death making as it were a recapitulation, returns upon herself with a retrograde motion, from the end of her race to the beginning of it, from whence she first issues thither she returns seeing the generation of living creatures from not being a living creature, is to be a living creature, as from a non entitie to be an entitie, so by the same steps, corruption passes from an entitie, to a non entitie whence it is, that that which in living creatures is last made, fails first, and that which is first made, fails last.

I have likewise observ'd, that there is really a heart in all animals, and not only (as *Aristotle* says) in the greater sort, and such as have blood, but likewise in lesse and such as have none, as those that are crufted without, or have shels, as house *Snails*, *Crabfish*, *Crevises*, *Shrimps*, and many others, nay in *Wasps*, *Hornets*, and in *Gnats*, by an optick glass made for the discovery of the least things, in the upper end of that place which is called their tail. I saw the heart beat, & shewed it to others.

But in those creatures which have no blood



blood, the heart beats very slowly & with deliberate strokes, as it does in other creatures which are dying, and is contracted leisurely, as in *Snails* is easie to discern, whose heart you shall find in the right side at the bottom of that *Orifice*, which it seems to open and shut for taking of air, and from whence it casts out foam, dissecting it at the top near the place which is answerable to the liver.

But it is to be observed likewise, that in Winter, and colder seasons, some creatures which have no blood, such as is the *Snail*, have nothing which beats, but doe rather seem to be like plants; as likewise the rest, which for that cause are called *Plant animals*. It is likewise to be observed, that in all creatures which have hearts, there are ears likewise, or some thing answerable to them, and wheresoever the heart has two ventricles, there are two ears, but not contrarily. But if you observe the fashioning of a chick in the egg, first of all there is in it as said only a bladder or drop of blood, which beats, and encreasing afterwards the heart perfected; so in some creatures (as not reaching a further perfection) there is a certain little bladder only like a point, red or white, as the beginning of life, as in *Bees, Wasps, Snails, Shrimps, Crayfishes*.

There is found here with us a sort of very little Fish; called in English, a *Shrimp*;

and in Low Dutch *Een Garneel*, usually taken in the Sea, and in the River of *Thames* all the bodie of which is transparent: This little Fish I have often shewn in water to some of my speciall friends, so that we could clearly discern the motion of the *heart* in that creature, the outward parts nothing at all obstructing our sight, as if it had been through a window. In a Hens egg shewed the first beginning of the Chick like a little cloud, by putting an egg out of which the shell was taken, into water warm and clear, in the midst of which cloud there was a point of blood which did beat, so little, that when it was contracted it disappeared, and vanish'd out of our sight, and in its dilatation, shew'd it self again, red, and small, as the point of a needle; insomuch as betwixt being seen, & not being seen, as it were betwixt being, and not being, it did represent a beating, and the beginning of life.

#### C H A P. V.

*The action and office of the motion of the Heart.*

**I** Confidently beleieve then, that out of these and the like observations, it will be found that the motion of the *heart* is after this manner.

First of all the *ear* contracts it self, and in that contraction throws the blood with which it abounds, as the head spring of the  
veins



*veins*, and the cellar and cistern of blood, into the *ventricle* of the heart, which being full, straightway the heart raises it self, stretches all the *nerves*, contracts the *ventricles*, and makes a pulsation: by which pulsation it continually thrusts that blood, (which by the *ears* is sent in) forth into the *arteries*, the *right ventricle* into the *lungs*, through that vessel which is called the *vena arteriosa*, but is indeed both in its place and function, and every thing else, an *arterie*; the *left ventricle* into the *aorta*, and so by the *arteries* into the whole body.

Those two motions, the one of the *ears*, the other of the *ventricles*, are so done in a continued motion, as it were keeping a certain harmony, and number, that they are both done at the same time, and one onely motion appears, especially in hotter creatures, whilst they move with a sudden motion. Nor is this otherwise done, than when in *Engines*, one wheel moving another, they seem all to move together; and in the lock of a piece, by the drawing of the spring, the flint falls, strikes the steel, fires the powder, enters the touch-hole, discharges, the balls flie out, pierces the mark, and all these motions by reason of the swiftnesse of them, appear in the twinkling of an eye: So likewise in the deglutition, the meat or drink is thrown into the *jaws*, the *larinx* is shut close, by its own *muscles*, and the *Epi-*

*glottis*, the top of the *weason*, is lifted up and opened by its *muscles*, just as a sack is raised to be filled, and opened that it may receive; it thrusts down the meat or drink being receiv'd, by the *thwarting muscles*, and with the *long muscles* sucks it down; yee notwithstanding that all these motions are made by severall and contradistinct *organs*, whilst they are don in harmony and order, seem but to make one motion and action, which they call swallowing.

So it comes to passe clearly, in the motion and action of the *heart*, which is a kind of swallowing, and transfusion of blood out of the veins into the arteries. And if any man carefully observing this, shall diligently search the motion of the *heart* in the dissection of any living thing, he shall see not only that which I have said, that the *heart* erects it self, and makes one continued motion with the *ears* of it, but likewise a certain motion and inclination side-ways, and an obscure leaning that way, in order to the draught of the *right ventricle*, so carrying on the work. As we may see when a Horse drinks, and swallows the water, at every gulp the water is sup'd down into the belly, which yeelds a certain noise and pulse to him that heeds him, and touches him; even so it comes to passe, that whilst some portion of the blood is drawn out of the *veins* into the *arteries*, there is a beating



ng which is heard within the breast.

The motion of the *heart* then is after this manner, and the transfusion and propulsi-  
on by mediation of the *arteries* is one of  
the actions of the *heart*, so that the pulsati-  
on which we feel, is nothing else but on-  
ly the impulsion of the blood by the *heart*.

But whether or no the *heart* contribute  
any thing else to the blood, besides the *tran-*  
*sposition*, *local motion*, and *distribution* of it,  
we must enquire afterwards, and collect out  
of other observations. Let this suffice for  
the present, that it is sufficiently evidenced,  
that in the beating of the *heart* the blood  
transfused and drawn out of the *veins*, in-  
to the *arteries*, through the *ventricles* of the  
*heart*, & so distributed into the whole body

But this all do in some manner grant  
and gather from the fabrick of the *heart*,  
and from the *figure*, *place*, and *use* of the  
*portals*, yet stumbling as it were in a dark  
place, they seem to be dim-sighted, and  
tamper up divers things, which are contra-  
dictory and inconsistent, and speak many things  
at random ( as we shewed before. ) One  
thing seemes to me to have been the chief  
rule of doubt and mistake in this businesse,  
which is, the contexture in a man of the  
*heart* and *lungs*; For when they did see  
the *vena arteriosa*, and the *arteria venosa*,  
coming likewise into the *lungs*, and there  
disappear, it could not sink with them

either how the *right ventricle* should distribute the blood into the body, or how the *left ventricle* should draw it out of the *vena Cava*. This *Galens* words do testify in his book *De plac. Hip. & Plat.* 6. Where he inveighs against *Erosistratus*, concerning the beginning and use of the *veins*, and the concoction of the blood. You will answer (sayes he) that it is so ordained, that the blood be prepared in the *Liver*, and so carried to the *Heart*, there to receive its proper form and absolute perfection: which truly seems not without reason; for no perfect and great Work is done suddenly, at one attempt and gains all its refining from one instrument which if it be so, shew us another vessel which draws out the blood, being absolutely perfected from the heart, and disposes of it as the arteries doe of the spirits through the whole bodie.

See here an opinion which carries reason with it left and rejected by *Galen*, because (besides not perceiving the passage,) he could not find a vessel which from the heart should distribute the blood into the whole body.

But if at that time in the defence of that opinion (which is now ours, & in all things else agreeable to reason by *Galens* own confession) one should with his finger have pointed out the great *Arterie* dispensing the blood from the *Heart* into the whole



whole body, what would that Divine man, most ingenious, and most learned, have answered? I wonder whether he would have said that the *arteries* distribute Spirits and not blood certainly he should not by this? sufficiently have confuted a *Erosistratus* who did imagine the Spirits to be contained in the *arteries* only, but should in the mean time contradict himself, and basely deny that, which in one of his own books he stiffly maintains to be true, proves it by many and strong arguments, and by experiments demonstrates it, that blood is naturally contain'd in the *arteries*, and not *Spirits*.

But if that Divine man, as he does often in the same place, do grant that all the *arteries* of the body do arise from the great *arterie*, and it from the *heart*, and professing likewise that those *three pointed doors* plac'd in the *Orifice* of the *Aorta* do hinder the return of the blood into the *heart*, and that nature had never ordain'd them for the best of our intralls, unless it had been for some speciall Office, I say, if the father of the Physicians should grant all these things, and in the same very words as he does in his forementioned book, I do not see how he could deny that the great *arterie* was such a vessel as did carry the blood, after it had received its absolute perfection, out of the *heart* into the whole body: Or perchance

chance he would stil continue to be doubte full, (as all the rest since his time to this verry day ) because not seeing the contexture of the *heart* with the *lungs* he was ignorant of the ways by which the Blood could be carried into the *arteries*, which doubt does not a little perplex the *Anatomists* when always in dissections they find the *arteria venosa* and the left *ventricle* full of thick knottie black blood, so that they are forc'd to affirm that the blood swets through the encloser of the *heart* from the *right ventricle* to the *left*; but this way I have sufficiently refuted already, therefore there must another way be prepared and laid open, which being found, there can, I imagine, be no difficulty, which can hinder any body from granting and confessing those things which I propounded before of the pulsation of the *heart*, and dispensation of the blood by the *arteries* into the whole body.

#### CH A P. VI.

*By which ways the blood is carried out of the vena cava, into the arteries, or out of the right ventricle of the heart into the left.*

Since it is probable, that the connexion of the *heart* with the *lungs* has given this occasion of mistake, they are to be blamed in this, who whilst they desire to give their verdict, to demonstrate, and under-



Understand all parts of living creatures, look but into man only, and into him being dead too, and so do no more to the purpose, than those, who seeing the manner of Government in one Common-wealth, take the same Politicks, or they who knowing the nature of one piece of Land, beleeve that they understand agriculture, or as if from one Particular proposition, they should goe about to frame Universal arguments.

Nevertheless were they but as well practis'd in the dissection of creatures, as they are in the Anatomie of mens carcases, in this business, which keeps them all in doubt and perplexitie, would in my opinion seem clear without all difficultie.

First of all in Fishes having but one *ventricle* of the *heart* (as having no *lungs*) the thing is clear enough. For it is certain, that it may be confirm'd before our eyes, that the *ladder* of blood, which they have at the bottom of the *heart*, answerable to the *aorta* of the *heart*, sends the blood into the *heart*, and that the *heart* does afterward, through a pipe or *arterie*, or something answering to an *artery*, openly transfuse it, both by our own view, and also by cutting the *arterie*, the blood leaping out upon every pulsation of the *heart*.

You may likewise see the same afterward easily in all other creatures, in which there is but one *ventricle* only, or something answering to it.

swerable to it, as in the *Toad, Frogg, Serpens, house-Snails*, which although they are said in some manner to have *lungs*, because they have a voice (of the frame of whose *lungs* I have many observations by me, which are not proper for this place: yet from our own eye sight it is clear, after the same manner in them that the blood by the pulsation of the *heart* is brought out of the *veins* into the *arteries*, the way of it open, patent, manifest, no occasion or doubt of difficulty at all. For the case is just so with them, as it might be with a man, the enclosure of whose *heart* were pierced through, or taken away, and so both the *ventricles* become one, I beleeve no man then would doubt which way the blood should go out of the *veins*, into the *arteries*.

And seeing there are more creatures which have no *lungs*, than there are which have, and more which have but one *ventricle*, than there are which have two, we may very well aver for the most part, and almost in all, that the blood is transfus'd out of the *veins*, into the *arteries*, through the bosom of the *heart* by an open passage.

But I conceiv'd with my self that it is plainly seen too in those *Embryons* which have *hearts*.

In a birth there are four vessells of the heart the *vena cava*, the *vena arteriosa*, *arteria venalis*, and the *aorta*, or *arteria magna*.



agna, and are otherwise united then in  
ne come to age, which all Anatomists  
now well enough.

The first touch and union of the *vena*  
*cava* with the *arteria venosa*, which comes  
to passe before the *vena cava* opens it self  
into the *right ventricle* of the *hart*, or sends  
out the *Coronal vein*, a little above its out-  
going from the *liver*, displays unto us its  
orifice side-ways, that is to say, a hole,  
wide and large, of an oval figure, made  
through passagable, from the *vena cava*  
into that *Arterie*: Insomuch as through  
that hole the blood may freely and abun-  
dantly passe out of the *vena cava*, into the  
*arteria venosa*, and the left ear of the *heart*,  
and so to the left *ventricle*. There is more-  
over against that place which looks to-  
wards the *arteria venosa* a *membrane* thin  
and hard, like a cover, which afterwards in  
those which grow to riper years, covering  
this hole, and growing together every way,  
does quite stop it, and takes away almost  
all signe of it. This \* *membrane*, I say, is so \* *Septum*.  
ordained, that hanging loosely with its own  
weight, it makes way into the *lungs*, and  
*heart*, and is turned up, giving passage to  
the blood which flows from the *vena cava*,  
but hinders it from flowing back into the  
*cava* again. So that from hence we may i-  
magin in an *Embryon*, that the blood ought  
continually to passe through this hole into  
the

the *arteria venosa*, out of the *vena cava*, and so into the left ear of the heart, and after it is enter'd, that it can never return.

The other union is that of the *vena arteriosa*, (which comes to passe after that the vein coming out of the right ventricle, is divided into two branches) and it is as if there were a third trunk, or arterial conduit-pipe diverse from the two former, from hence crookedly drawn, and perforate into the *Arteria magna*; so that in the dissection of *Embryons*, there appears as it were two *aortas*, or two roots of the great arterie. This conduit likewise in those that come to ripeness is attenuated by little and little, and fades away, and at last is quite dried up, & lost, like the *Umbilical vein*. This arterial conduit-pipe hath no membrane to hinder the motion of blood backward, or forward, for there are in the orifice of that *vena arteriosa*, of which this conduit-pipe as I said before is a branch, three \* doors of the fashion of a  $\Sigma$ . which appear outwardly and inwardly, and doe easily give passage to the blood flowing into the right ventricle by this way, but on the contrary hinder any thing which may flow from the arterie or the lungs into the right ventricle, which they shut very close: So that here we have reason to think, that in an *Embrion* when the heart contracts it self, the blood must alwayes be carryed out of the right ventricle

\*Valvulae.



into the *arteria magna* by this way.

In answer to that which is commonly spoken, that these two conjunctions, so great, so open, so wide, were made for the nourishing of the *lungs*, and that in those who arrive to riper age, when the *lungs* by reason of their heat and motion require more abundant nutriment, they should be taken away, and made up, is an invention improbable, and inconsistent. And that is likewise false which they say of the *heart* of an *Embryon*, that it is idle and does nothing, moves not at all: whence it comes to passe, that Nature was forc'd for the nourishing of the *lungs* to make those passages; when by our own eyes it is made plain to us, that both in an egg whereon a Hen hath sat, and in *Embryons* newly cut out of the womb, the *heart* doth move as in those of riper age; and likewise, that Nature is oppress'd with no such necessity: Of which motion not only these my eyes have often been Witnesses, but likewise *Aristotle* himself affirms; *The pulse* (says he) *appears at the very beginning in the constitution of the heart, which is found in the dissection of living creatures, and by an egg in the forming of the Chick.* But we also observe, that those passages are open and free, aswell in men, as also in other creatures, not only to the time of the birth, which the Anatomists have observ'd, but likewise many months after

after: yea in some for many years, if not :a  
their life-time, as in the *Goose*, and ver  
many Birds. Which thing perchance di  
deceive *Botallus*, so that he affirm'd, Tha  
he had found a new passage for the blood  
out of the *venacava* into the *left ventricl*  
of the *heart*. And I doe confesse, Tha  
when I my self first found this in a *Rat*  
full growth, that I did imagine some suc  
thing. From which it is understood, tha  
in the unripe births of mankind, and like  
wise in others, in which these unions are  
not taken away, this very thing falls out  
that the *heart* by its motion brings forth  
the blood from the *venacava* openly, and  
by very patent ways, by the drawing  
both its *ventricles*. For the *right* receiving  
the blood from the *ear*, thrusts it forth  
through the *vena arteriosa*, and its bran  
called *canalis arteriosus*, into the great *ar*  
*terie*. Likewise, the *left* at the same tim  
by the mediation of the motion of the *ear*  
receives that blood, which is brought into  
the *left ear* through that oval hole from  
the *venacava*, and by its *tention* and *con*  
*striction* thrusts it through the root of the  
*Aorta* into the great *arterie* likewise. S  
in *Embryons* whilst the *lungs* are idle, and  
have no action nor motion (as if there were  
none at all) Nature makes use of both the  
*ventricles* of the *heart*, as of one for tran  
mission of blood. And so the condition



*Embryons* that have *lungs* and make no use of them, is like to the condition of those creatures which have none at all.

Therefore in these likewise the truth appears as clearly, that the *heart* by its pulsation brings forth, and transfuses the blood out of the *vena cava*, into the great *arterie*, and by as open ways as if both the *ventricles* (as I said before) were made pervious to one another, by taking away the partition betwixt them. Therefore seeing for the most part these wayes are open in all creatures at some times, which do serve for transmission of blood through the *heart*, it now remains that we enquire whether why in some creatures, as in men, and those hotter, and of riper age, we do hold that not to be performed through the substance of the *lungs*, which nature did before in an *Embryon* through those passages (at that time when there was no use of *lungs*;) which she seems to have made of force or want of passage through the *lungs*. Or why it is better that Nature (for Nature always does that which is best) hath altogether shut up those open ways, of which she before made use in the *Embryon*, and in the birth, and in all other creatures does make use of, nor in the lieu of them hath found out any other passage for the blood, but hinders it altogether after this manner. So then the business is arriv'd to this, that

to those who search for the *veins* in man (by which the blood passes out of the *vena cava* in the left *ventricle*, and into the *arteria venosa*) it were more worth their pains, and wiselier done, if from the dissection of living creatures they would search the truth, why in greater, and more perfect creatures, and those of ripe age, nature would rather have the blood to be squeezed through the *streyner* of the *lungs*, than through most patent passages as in other creatures: and then they would understand that no other way nor passage could be excogitated.

Whether this be, because that greater and perfecter creatures are hotter, and when they come to be of age, their heat is apter to be suffocated and to be inflamed, and therefore the blood is *streynd* and sent through the *lungs* that it may be tempered by breathing in the air upon it, and freed from over-heating and suffocation, or some such other thing. But to determine and give a reason of this is nothing else but a search for what the *lungs* were made. And thus much concerning them and their use, & all manner of cooling, of the necessity & use of air, & the like, of several and different organs made in *animals*. For this cause although by observation I have found out a great many things, yet lest I should seem by straying from my purpose, of the mo-



on of the heart, to go besides my intention, and leave my task to confute the business, and decline it; I shall leave these things fitter to be set forth in a Treatise by themselves; and that I may return to my former purpose, I will goe on to prove what remains. And first I prove, that in the more perfect *Animals* and those come to age, as Man, the blood may passe from the right ventricle of the heart by the *vena arteria*, to the lungs, and from thence through the *arteria venosa* into the left ear, and from thence into the left ventricle of the heart, and then that it is so.

C H A P. VII.

That the blood does passe from the right ventricle of the heart, through the streyner of the lungs, into the *arteria venosa*, and left ventricle of the heart.

It is well enough known that this may be, and that there is nothing which can hinder if we consider which way the water passing through the substance of the earth, with procreate Rivulets and Fountains; or we do consider how sweat passes through the skin, or how urine flowes through the streyner of the reins: It is to be taken notice of in those that make use of the waters of the Spaw, or de la Madonna, as they call them in Padua, or other brackish or vis-

trisolated waters; or those who in carrow sing swill themselves with drink, that in an hour or two they pisse all this through their bladder. This great quantity ought to stay a while in concoction, it ought to flow through the *liver*, (as they confess that the juyce of the nourishment we receive doth twice a day) so ought it through the *veins*, through the *streynes* of the *reins* and through the *ureters* into the *bladder*.

Those therefore which I hear denying that blood, yea the whole masse of blood may passe through the substance of the *lungs*, as well as the nutritive juice through the *liver*, as if it were impossible, and in wayes to be beleaved; It is to be thought that those kind of men, I speak with the *Ped* et, where they like, they easily grant, where they like not, by no means: Here where need is, they are afraid, but where no need is they are not afraid to aver. The *streynes* of the *liver*, and of the *reins* too, much thicker than that of the *lungs*, because they are far thinner woven, and of a spongius substance, if they be compared to the *liver* and *reins*.

In the *liver* there is no impulsive, no strength forcing; in the *lungs*, the blood thrust against them by the impulsion of the *right ventricle* of the *heart*, by which impulsion theremust necessarily follow a distention of the vessels, and porosities of the *lungs*.



besides, the *lungs* in respiration rise and fall, *alen de usu part.* By which motiō it follows of necessity, that the porosities of them and their vessels are open'd and shut, as it falls out in sponges, & all things of a spongy substance when they are constricted and dilated again; On the contrary, the *liver* is at rest, nor is it seen at any time to be so constricted and dilated.

Last of all, Since through the *liver*, there is none but affirms, that the juice of all things we receive may passe into the *vena cava*, both in Men, Oxen, or the greatest creatures, and that for this reason, because it must passe some way into the *veins* if there be any nutrition, and there is no other way, and for that cause they are forced to affirm this: Why should they not likewise believe this of the passage of the blood through the *lungs* in men come to age, upon the same arguments? And with *Columbus*, a most skilful and learned *Anatomist*, believe and assert the same from the structure and largeness of the *lungs*; because that the *Arteria venosa*, and likewise the *ventricle*, are alwayes full of blood, which must needs come hither out of the *veins*, by no other path, but through the *lungs*; as both he and we from our words before, our own eyesight, and other Arguments, do believe to be clear:

But seeing there are some such persons

which admit of nothing, unlesse there be an authority alleged for it; let them know that the very same truth may be proved from *Galen's* own words, that is to say, not onely that the blood may be transfused out of the *vena arteriosa*, into the *arteria venosa*, and thence into the *left ventricle* of the heart, and afterwards transmitted into the arteries; but also that this is done by the continued pulse of the heart, & motiō of the lungs, whilst we breath. There are in the orifice of the *vena arteriosa* 3. shuts, or doors, made like a  $\Sigma$ , or half-Moon, which altogether hinder the blood sent into the *ve. a arteriosa* to return to the heart, which all know.

*Galen* expresses the use and necessity of those shuts, in these words, *De usu* part: 6. Cap. 10. In all (sayes he) there is a mutual *Anastomosis* or opening of the veins, together with the arteries, in their kissing, and they borrow both blood and spirit from one another by invisible and very narrow passages. But if the very mouth of the *Vena Arteriosa* had alwayes stood open, and Nature had found no device to shut it, when it was requisite, and to open it again, it could never have come to passe that by those invisible and little kisses, the Thorax being contracted, the blood could be transfused into the arteries. For every thing is not from any thing extracted and emitted after the same manner; for as that which is light is easilier attracted than that which



which is heavy, by dilatation of the instruments, and by the constriction is squeezed out again; so any thing is easier attracted through broad passage, than through a narrow passage, and so sent forth again. But when the Thorax is contracted, the Arteria Venosa which is in the Lungs, being on every side pulsated, and compress'd together strongly, doe squeeze out very quickly the Spirit that is in them, and doe borrow through those fine tubes a part of the blood, which truly could never come to passe, if through that great opening, such as is the Vena Arteriosa, the blood should return back to the Heart: Now the return of it through that great mouth being stop'd, some of it through those small orifices does drop into the Arteries, it being press'd every way. And a little after in the following Chapter, How much the more the Thorax endeavours to squeeze out the blood, so much the more those Membranes, that is to say those three Sygma-like doors, do clostlier shut the mouth of it, and suffer nothing to return. Which he says likewise in the same tenth Chapter a little before. Unlesse there were doors there would follow a three fold inconvenience, for so the blood should make such a long journey but in vain, by flowing in the Diastoles of the Lungs, and filling all the veins in the, in the Systoles, as it were a neap tide, like Euripus reciprocating its motion again and again, hither and

## Anatomical Exercises

thither, which would not be convenient for the blood: But this may seem no great matter, but that in the mean time it should weaken the benefit of respiration, this is no more to be counted a small business. And a little after, And likewise the third inconvenience would follow, no slight one, when in our breathing our blood should return backwards, unlesse our Maker had ordain'd the naturall position of those Membranes. Whence he concludes, ch. 2. Indeed the use of all the Suburbs or portals is the same, to hinder the return of the matter, & either of the have a proper use, to draw matter from the heart, that they may return no more, and to draw matters into the heart, that they may goe no more from thence. For Nature would not have the heart to be wearied with needless travel, nor send thither whence it was better to extract, nor extract from thence again whither it was better to send. For which cause there being four orifices onely, two in either Ventricle, one takes in, the other draws forth. And a little after. Furthermore, when one of the vessels consisting of but of one Tunicle is implanted into the Heart, and the other consisting of a double Tunicle is drawn forth from it, viz. (The right ventricle Galen means, so do I the left ventricle by the same reason). It was needfull that there should be as it were a cistern to both, to which both of them belonging, that the blood might be drawn out by one,



...e, and sent out by the other.

That argument which *Galen* brings for the passages of the blood through the right ventricle out of the *vena cava* into the lungs, we may more rightly use for the passages of the blood out of the veins through the heart into the arteries changing only the terms.

It does therefore clearly appear from the words and places of *Galen*, a divine man, Father of Physicians, both that the blood both pass from the *vena arteriosa* into the little branches of the *arteria venosa*, both by reason of the pulse of the heart and also because of the motion of the lungs and thorax: See the commentarie of the most learned *Hofmannus* upon the sixth Book of *Galen de usu Part* which book I saw after I had written these things.

Furthermore it was necessary that the heart should receive the blood continually into the ventricles, as in a pond or cistern, and send it forth again: and for this reason it was necessary that it should be serv'd with four locks or doors, whereof two should serve for the intromission and two for the emission of blood, lest either the blood like an *Euripus*, should inconveniently be driven up and down, or goe back thither from whence it were fitter to be drawn, and flow from that part to which it was needfull it should have been sent, and so

so should be wearied with idle travell, and the breathing of the *lungs* be hindred. Lastly our assertion appears clearly to be true, that the blood does continually & incessantly flow through the porosities of the *lungs*, out of the *right ventricle* into the *left*, out of the *vena cava* into the *arteria magna*; for seeing the blood is continually sent out of the *right vètricle* into the *lungs* through the *vena arteriosa*, and likewise is continually attracted out of the *lungs* into the *left*, which appears by that which has been spoken, and the position of the *Portalls*, it cannot be, but that it must needs pass through continually.

And likewise seeing that always, and without intermission, the blood enters into the *right ventricle* of the *heart*, and goes out, (which is likewise manifest, of the *left ventricle*, both by reason and sense) it is impossible but that the blood should pass continually through, out of the *vena cava* into the *Aorta*.

That therefore which is apparent to be done in most, and really in all whilst they are growing to age, by dissection through most open passages, is here likewise manifest to come to pass in those when they are arriv'd to full age, by the hidden porosities of the *lungs*, and touches of its vessels, both by *Galens* words, and that which has been spoken: From whence it appears, that albe-



one *ventricle* of the *heart*, that is the *left*, were sufficient for the dispensation of the blood through the whole body, and the ex-  
 uction of it out of the *vena cava* (as it is in all creatures which want *lungs*) Yet Nature desiring that the blood should be strained through the *lungs*, was forc'd to add the *right ventricle*, by whose pulse the blood should be forc'd through the very *lungs* out of the *vena cava* into the receptacle of the *left ventricle*: and so it is to be said that the *left ventricle* was made for the *lungs* sake, and not for nutrition only; seeing in such an abundance of victuall, adding to it the help of compulsion, it is no ways to be believ'd that the *lungs* should rather want so much aliment, and that of blood so much more pure and full of spirit, as being immediately conveyd from the *ventricles* of the *heart*, than either the most pure substance of the *brain*, or the most resplendent and divine constitution of the *eyes*, or the flesh of the *heart* it self, which is more fitly nourished by the *vena coronalis*.

## C H A P. VIII.

*Of the abundance of blood passing through the  
Heart out of the veins into the arteriess  
and of the circular motion of the blood.*

**T**HUS much of the transfusion of the blood out of the *veins* into the *arteriess* & how it is disposed of and transmitted by the pulse of the *heart*, to some of wch those perchance that were heretofore moved by the reasons of *Galen*, *Columbus*, and others, will yeeld; now as concerning the abundance and increase of this blood, which doth pass through, those things which remain to be spoken of, though they be very considerable, yet when I shall mention them, they are so new and unheard of, that not only I fear mischief which may arise to me from the envy of some persons, but I likewise doubt that every man almost will be my enemy, so much does custome and doctrine once received and deeply rooted (as if it were another Nature) prevail with every one, and the venerable reverence of antiquity enforces: Howsoever, my resolution is now set down, my hope is in the candor of those which love truth, and learned spirits. Truly when I had often and seriously considered with my self, what great abundance there was, both by the dissection and living things, for experiments



ments sake, and the opening of *arteries*, and many ways of searching, and from the *metrie*, and magnitude of the *ventricles* of the *heart*, and of the vessels which goe into it, and goe out from it, (since Nature making nothing in vain, did not allot that greatness proportionably to no purpose, to those vessels) as likewise from the continued and carefull artifice of the *doores* and *fibers*, and the rest of the *fabrick*, and from many other things; and when I had a long time considered with myself how great abundance of blood was passed through, and in how short time that transmission was done, whether or no the juice of the nourishment which we receive should furnish this or no: at last I perceived that the *veins* should be quite emptied, and the *arteries* on the other side be burst with too much intrusion of blood, unless the blood did pass back again by some way out of the *veins* into the *arteries*, and return into the *right ventricle* of the *heart*.

I began to bethink myself if it might not have a *circular motion*, which afterwards I found true, and that the blood was thrust forth and driven out of the *heart* by the *arteries* into the habite of the body and all parts of it by the beating of the *left ventricle* of the *heart*, as it is driven into the *Lungs* through the *vena arteriosa* by the beating of the *right*, and that it does return

turn through the little *veins* into the *vena cava*, and to the *right ear* of the *heart*, and likewise out of the *lungs* through the aforesaid *arteria venosa* to the *left ventricle*, as we said before.

Which motion we may call *circular*, after the same manner that *Aristotle* sayes that the rain and the air doe imitate the motion of the superiour bodies. For the earth being wet, evaporates by the heat of the *Sun*, and the vapours being rais'd aloft are condens'd and descend in showrs, and wet the ground, and by this means here are generated, likewise, tempests, and the beginnings of meteors, from the circular motion of the *Sun*, and his approach and removall.

So in all likelihood it comes to passe in the body, that all the parts are nourished, cherished, and quickned with blood, which is warm, perfect, vaporous, full of spirit, and that I may so say, alimentative: in the parts the blood is refrigerated, coagulated, and made as it were barren, from thence it returns to the *heart*, as to the fountain or dwelling-house of the body, to recover its perfection, and there again by naturall heat, powerfull, and vehement, it is melted, and is dispens'd again through the body from thence, being fraught with spirits, as with balsam, and that all the things do depend upon the motional pulsation of the *heart*;



So the *heart* is the beginning of life, the  
sun of the *Microcosm*, as proportionably  
the *Sun* deserves to be call'd the *heart* of the  
world, by whole vertue, and pulsation, the  
blood is mov'd, perfected, made vegetable,  
and is defended from corruption, and mat-  
tering; and this familiar household-god  
doth his duty to the whole body, by nour-  
ishing, cherishing, and vegetating, being  
the foundation of life, and author of all.  
But we shall speak more conveniently of  
these in the speculation of the finall cause  
of this motion.

Hence it is, seeing the *veins* are certain  
ways or vessels carrying the blood, there are  
two sorts of them, the *Cava* and *Aorta*.  
Not by reason of the side, as *Aristotle* says,  
but by their function; and not, as is com-  
monly spoken, by their constitution, seeing  
in many Creatures (as I have said) a *vein*  
differs not from an *arterie*, in the thicknesse  
of the *Tunicle*, but by their use and em-  
ployment distinguishable, a *vein* and an *ar-*  
*terie*, both of them not undeservedly called  
*veins* by the Antients, as *Galen* has obser-  
ved, because that this, *viz.* the *arterie*, is  
a way carrying the blood from the *heart* in-  
to the habit of the body, the other a way  
carrying it from the habit of the body back  
again into the *heart*. This is the way from  
the *heart*, the other the way to the *heart*.  
This contains blood rawish, unprofitable,  
and

and now made unfit for nutrition, the co-  
ther blood digested, perfect, and alimern-  
tative.

## CHAP. IX.

*That there is a Circulation of the blood from  
the confirmation of the first supposition.*

**B**UT lest any should think that we put  
cheat upon them, and bring only faint  
assertions, without any ground, and inno-  
vate without a cause; there comes three  
things to be confirm'd, which being seen  
down, I think this truth must needs follow  
and be apparent to all men.

1. First, That the blood is continually  
and without any intermission, transmitted  
out of the *vena cava* into the *arteries*, in  
so great abundance, that it cannot be re-  
cruited by those things we take in, and in-  
somuch that the whole masse of blood  
would quickly pass through.

2. In the second place, that continually  
duly, and without cease, the blood is driven  
into every member and part, and enters by  
the pulse of the *arteries*, and that in far  
greater abundance than is necessary for  
nourishment, or than the whole mass is a-  
ble to furnish.

3. And



3. And likewise thirdly, that the *veins* themselves doe perpetually bring back this blood into the mansion of the *heart*.

These things being prov'd, I think it will appear that it doth go round, is returned, thrust forward, and comes back from the *heart* into the extremities, and from thence into the *heart* again, and so makes it were a circular motion.

Let us suppose how much blood the *left ventricle* contains in its *dilatation* when it is full, either by our thought, or experiment, whether  $\frac{3}{4}$ ij, or  $\frac{3}{4}$ ijj, or  $\frac{3}{4}$ j s, I have found a dead man above  $\frac{3}{4}$ ij.

Let us suppose likewise, how much less in the contraction, or when it does contract itself, the *heart* may contain, and how much more capacious the *ventricle* is, and from thence how much blood is thrust out of the *arteria magna*: for in the *Systole* there is always some thrust forth, which was demonstrated in the third Chapter, and all men acknowledge, being induced to beleieve it from the *fabrick* of the vessels; by a very probable conjecture we may aver that there is sent in of this into the *arterie* a fourth, fifth, or sixth, at least an eighth part. So let us imagine, that in a Man there is sent forth in every pulse of the *heart*, an ounce and a half, or three drams, or one dram of blood, which by reason of the hindrance of the portals cannot return to the *heart*.

D

The

The *heart* in one half hour makes above a thousand pulses, yea in some, and at some times, two, three, or four thousand; now multiply the drams either a thousand times three drams, or two drams, or five hundred ounces, or such a proportionate quantity of blood, transfus'd through the *heart* into the *arteries*, which is a greater quantity than is found in the whole body. So likewise in a Sheep or a Dog if there passe (I grant ye) but one scruple, in one half hour there passes a thousand scruples, or about three pounds and a half of blood: in whose body for the most part is not contained above four pounds of blood, for I have tryed it in a Sheep.

So our account being almost layd, according to which we may guesse the quantity of blood which is transmitted, counting the pulsations, it seems that the whole masse of blood does passe out of the *veins* into the *arteries* through the *heart*, and likewise through the *lungs*.

But grant that it be not done in half an hour, but in a whole hour, or in a day, be it as you will it is manifest that more blood is continually transmitted through the *heart*, than either the food which we receive can furnish, or is possible to be contain'd in the *veins*. Nor is it to be said that the *heart* in its contraction sometimes does thrust out, sometimes not, or as much



as nothing, or something imaginary. This  
 I refuted before, and besides its against  
 sense or reason. For if in the dilatation  
 of the *heart* it must needs come to passe  
 that the *ventricles* are filled with blood, it  
 is likewise necessary that in its contraction  
 it should alwayes thrust forth; and that  
 not a little, seeing the conduits are not smal;  
 and the protrusion not seldome: its very  
 inconvenient likewise in every propulsion,  
 the proportion of the blood thrust out  
 should be a third part, or sixth part, or  
 eighth part in proportion to that which is  
 before contain'd in the *ventricle*, and which  
 did fill it in the dilatation, according as the  
 proportion of the *ventricle* being contra-  
 cted is to the proportion of it being incon-  
 tracted; and as in the dilatation it never  
 comes to passe, that it is ever fill'd with  
 nothing, or something meerly imaginary,  
 so in the contraction it never expells no-  
 thing, or that which is imaginary, but al-  
 wayes something, according to the pro-  
 portion of the contraction. Wherefore it  
 is to be concluded, that if in a Man, a Cow,  
 or a sheep, the *heart* doth send forth one  
 dram, and that there be a thousand pulses  
 in one half hour, that it shall come to passe  
 in the same time that there shall be ten  
 pounds and five ounces transmitted, if at  
 one pulse it send forth two drams, twenty  
 pound and  $\frac{3}{4}$  10, if half an ounce forty one  
 D 2 pounds

pounds and  $\frac{3}{8}$ , if an ounce,  $\frac{83}{16}$ , and  $\frac{3}{4}$  will come to be transfus'd, I say, in half an hour, out of the *veins* into the *arteries*.

But it may perchance be that I shall set down here more accurately how much is thrust out at every pulsation, when more, and when less, and for what reason, out of many observations which I have gathered.

In the mean time this I know and declare to all men, that sometimes the blood passes in less, sometimes in more abundant quantitie, and the circuit of the blood is perform'd sometimes sooner, sometimes slower, according to the age, temperature, external and internal cause, accidents natural or innatural, sleep, rest, food, exercise, passions of the mind, and the like.

But howsoever, though the blood passes through the *heart* and *lungs*, in the least quantitie that may be, it is conveyd in far greater abundance into the *arteries*, and the whole body, than it is possible that it could be supplied by juice of nourishment which we receive, unless there were a regress made by its circuit.

This likewise appears by our sense, when we look upon the dissection of living things, not only in the apertio of the great *arteries*, but (as *Galen* affirms in man himself) if any yea the least *arterie* be cut, all the mass of blood will be drain'd out of the whole bo-

dy



dy, as well out of the *veins* as out of the *artertes*, in the space of half an hour.

Likewise Butchers can well witness this, when in killing of an oxe, they cut the jugular *arteries*, they drain the whole mass of blood in less than a quarter of an hour, and empty all the vessels, which we find likewise to come to pass in cutting off members and tumours, by too much profusion of blood, sometimes in a little space.

Nor does it weaken the force of this argument, that some will say, that in slaughter, or of cutting off members, the blood flows out as much through the *veins* as through the *arteries*, seeing the business is far otherwise. For the *veins*, because they flap down, and that there is no out-driving force in them, and because their composition is likewise with stoppages of portalls, as hereafter shall appear, they shed but a very little, but the *arteries* pour out the blood more largely, impetuously, by impulsion, as if it were cast out of a spout. But let the case be tryed omitting the *vein* and cutting the *jugular arterie* in a sheep or a dog, it will be wonderfull to see, with how great force, how great protrusion, how quickly, you shall see all the blood to be emptied from the whole body, as well from the *veins* as from the *arteries*. But it is manifest by what we have said, that the *arteries* receive blood no where else but from

the *veins* by transmissi<sup>o</sup>n through the *heart*, wherefore tying the *aorta* at the root of the *heart*, and opening the *jugular* or any other *arterie*, if you see the *arteries* empty, and the *veins* only full, it is not to be wondered at.

Hence you shall plainly see the cause in *Anatomic* why so much blood is found in the *veins*, and but a little in the *arteries*, why there is a great deal found in the *right ventricle*, and but a little in the *left*, (which thing perchance gave occasion of doubt to the antients, and of beleev<sup>ing</sup>, that spirits alone were containd in those concavities, whilst the animal was alive) the cause perchance is, because there is no passage afforded from the *veins* into the *arteries* but through the *lungs* and the *heart*, but when the *lungs* have expir'd and leave off to move, the blood is hinder'd to passe from the little branches of the *vena arteriosa* into the *arteria venosa*, and so into the *left ventricle* of the *heart* (as in an *Embryon* it was before observed, that it was stopt by reason of the want of motion of the *lungs*, which open and shut up the touches, and hidden and invisible porosities) but seeing the *heart* does not leave off motion at the same time with the *lungs*, but does beat afterwards and outlive them, it comes to pass that the *left ventricle* and the *arteries* do send forth  
blood



ood into the habit of the body, and not receiving it through the *lungs*, doe there-  
fore appear empty.

But this likewise affords no small credit to  
our purpose, since there can be no other  
cause given for this but what in our suppo-  
sition we have alleged.

Besides, from hence it is manifest, that  
how much the more, or more vehemently  
the *arteries* doe beat, it happens in all fluxes  
of blood that so much the sooner the  
whole body is emptied.

Hence likewise it comes to pass, that in  
faintings, all fear, and the like, when  
the *heart* beats more weakly, languishing,  
and with no force, that it happens that all  
fluxes of blood are stop'd and hindred.

Hence likewise it is, that in a dead body,  
after the *heart* ceases to beat, you cannot  
draw out of the *jugular* or *crural* veins and open-  
ing of the *arteries* by any means extract  
above half the mass of blood, nor can a but-  
cher when he hath knockt the ox on the  
head, and stund him, draw all the blood  
from him unless he cut his throat before the  
heart leaves beating.

Last of all, from hence we may imagine  
that no man hitherto has said any thing a-  
bout concerning the *Anastomosis*, where  
it is, how it is, and for what cause; I am  
now in that search.

## C H A P. X.

*The first supposition concerning the quantity of the blood which passes through from the veins into the arteries, and that there is a circulation of the blood is vindicated from objections, and further confirm'd by experiments.*

**T**HUS far the first position is vindicated, whether the matter be to be reckoned by account, or whether we refer it to experiment, or our own eye-sight, *viz.* that the blood continually passes out of the veins into the arteries in greater abundance than can be furnished by our nourishment; so that the whole masse in a little time passing through that way, it must necessarily follow that there should be a circulation, and that the blood should return.

But if any here can say that it can pass through in great abundance, & yet it is not needfull that there should be a circulation, since it comes to be made up by what we receive, and that the encrease of milk in the paps may be an instance, for a cow in one day gives three, four, or seven gallons, or more, a woman likewise gives two or three pints every day or more, in the nursing of a child or two, which is manifest to be restor'd by what she receives, it is to be



he answer'd, that the heart is known to send out so much in one hour or two.

8 But if not as yet satisfyed he shall still adresse further, and say, that although by the dissecting of an *arterie*, and giving and opening a way, it comes to passe besides the course of Nature, that the blood is forcibly pour'd out, yet it does not therefore come to passe in an entire body, no outlet being given, and the *arteries* being full, and constituted according to Nature, that such a great quantity should passe in so short space, insomuch that there must needs be a regresse; It is to be answer'd, that by laying of an account it appears from former reckoning, that how much the *heart* being filld does contain more in its dilatation, than in its constriction, so much (for the most part at every pulsation is sent forth, and for that cause does there so much passe the body being whole, and constituted according to Nature.

But in *Serpents*, and in some *Fishes*, binding the veins a little beneath the *heart*, you shall quickly see the distance betwixt the *heart* and the *Ligature* to be emptied, so that you must needs affirm the recourse of blood, unless you will deny your own *eye-sight*. The same shall clearly appear afterwards in the confirmation of the second supposition.

Let us conclude, confirming all these with one

one example, that every one may beleeve  
his own eyes: If any one cut up a live *Ad-*  
*der*, he shall see the *heart* beat calmly, di-  
stinctly, for a whole hour, and so contract  
its self, (in its constriction being oblong))  
and thrust it self out again like an  
Worm. That it is whitish in the *Systole*,  
and contrary in the *Diastole*, together with  
all the rest, by which I said this truth was e-  
vidently confirmed, for here the parts are  
longer and more distinct. But this we may  
more especially find, and clearer than the  
noon-day.

The *vena cava* enters the lower part of  
the *heart*, the *arterie* comes out at the up-  
per part, now taking hold of the *vena ca-*  
*va* with a pair of pinfers, or with your  
finger and thumb, and the course of the  
blood being stop'd a little way beneath the  
*heart*, you shall upon the pulse perceive  
to be presently almost emptyed that place  
which is betwixt your fingers and the  
*heart*, the blood being exhausted by the  
pulse of the *heart*; and that the *heart* will  
be of a far whiter colour, and that it is les-  
ser too in its dilatation for want of blood,  
and at last beats more faintly, insomuch  
that it seems in the end as it were to die; so  
soon again as you untie the *vein* both co-  
lour and bignesse returns to the *heart*. Af-  
terwards, if you do leave the *veins*, and doe  
grasp or bind the *arterie* a little way from  
the



heart, you shall on the contrary see it swell vehemently there where they are stop'd, and that the heart is swell'd beyond measure, and does acquire a purple colour and it be blackish again, and that it is at last prest with blood so that you would think it would be suffocated, but untying the string, that it does return to its natural constitution, colour, and bignesse.

So now there are too sorts of death, extinction, by reason of defect; and suffocation, by too great quantity: here you may have the Example of both before your eyes, and confirm the truth which hath been taken concerning the heart, by your own view.

## CH A P. XI.

*The second supposition is confirmed.*

The second is to be confirm'd by us, which that it may appear the clearer to our view, some experiments are to be taken notice of, by which it is clear, that the blood doth enter into every member through the arteries, and does return by the veins, and that the arteries are the vessels carrying the blood from the heart, and that the veins are the vessels and wayes which the blood is return'd to the heart it self; and that the blood in the members

*Anatomical Exercises*

members and extremities does passe from the *arteries* into the *veins* (either immediately by an *Anastomosis*, or immediately through the porosities of the *flesh*, or both wayes) as before it did in the *heart* and *thence* out of the *veins*, into the *arteries* whence it is manifest, that in its *circulation* it moves from thence hither, and from hence thither, to wit, from the *centre* of the *extremities*, and from the *extremities* again to the *centre*.

But likewise computatio being afterwards made, it appears in the same place, that in regard of the abundance it can neither be recruited by that which we take in, nor is there so much requir'd for nourishment. Likewise concerning *ligatures* it is clear how they attract, that they do it not either by heat, nor grief, or force of *vacuum*, nor any other cause known heretofore. As likewise what convenience and use *ligatures* can bring to Physick, how they stop, or provoke the flux of blood, and how they cause *gangrenes*, and mortifications of the members and by this means how they are of use in the gelding of some creatures, and in taking away of *fleshy tumors*, and *wens*. For certainly from hence it comes to passe, that none have rightly understood the cause and reasons of all these things, though almost according to the opinion of the *Arabs*, do propound and give their verdict for



*Ligatures* in diseases, yet few in the administration of them doe afford any help in their cures.

Some *ligatures* are *strict*; others of a *middle sort*:

A *strict ligature* I call such a one, where the arm is so streightly bound with the band or rope, that you cannot perceive the *arterie* to beat any where beyond the *ligature*; such a one we use in the cutting off of members, taking a care of the flux of blood, in gelding of *animals*, taking away *tumors*: by which *ligature* the afflux of ment and heat being altogether intercepted, the vessels, the testicles, fade and dry, all the great *tumors* of flesh, and afterwards to fall quite away.

That I call a *middle sort of ligature*; which does compress the member every way, but without pain, insomuch that it suffers the *arterie* to beat a little beyond the *ligature*; such a one as is used in the attraction and emission of blood: for albeit you make the *ligature* above the elbow, yet you shall perceive the *arteries* to beat a little in the wrist if you touch it, if in the hand-letting the *ligature* be made aright.

Now let there be an experiment made in mans arm, either taking a band, such as they use in blood letting, or by the stronger grasp of the hand it self, which indeed is most conveniently done in a lean body which

which has larger *veins*, and when the body being heated, the extremities are warmed and a greater quantitie of blood is in the extremities, and more vehement pulsations, for then all things will more evidently appear.

If you doe make then a hard *ligature* drawing it as streight as any can endure: you may first observe that beyond that *ligature* the *arterie* does not beat in the *wrist*, nor any where else, and then this immediately the *arterie* begins above the *ligature*, has its *Diastole* higher, and beats more vehemently, and does as it were with a kind of tide rise towards the *ligature* (as if it did indeavor to beat through the open its flux which is intercepted) and the passage which is stopt, and that it does appear to be fuller there than is convenient. In the mean time the hand retains its colour and constitution, only in process of time it begins to be a little coldish, but nothing is attracted into it.

After that this *ligature* has continued while, and that in a sodain it is a little untied into a middle sort, such I say as the use in letting of blood, it is to be observed that the whole hand is streightways imbrued with colour, and distended, and that the *veins* of it become swelld and lumpie, and that in the space of ten or twelve pulses the blood being thrust forward and cast into the



the hand is seen to be extreme full, and that great quantitie of blood is quickly drawn to the *ligature*, without either anguish, heat, or shunning of the *vacuum*, or any other cause heretofore mentioned.

In the mean time, if any one put his finger in the *arterie*, in the very time of the unbinding, near to the *ligature*, he shall feel the blood as is were passing by under his finger. Moreover he in whose arm the experiment is made, upon the change of a *streight* *arterie* into a *middle one* (the impediment passing as it were removed) he shall plainly feel the heat and blood enter by pulsation, and perceive something to be breathed by the conduct of the *arterie* as it were immediately, and to be dispersed over all his hand, and that his hand is presently heated and distended. As in a *strict ligature* the *arteries* above are distended, and do swell, and not below, and the *veins* become lesser, so in the *middle sort* of *ligature* the *veins* swell, and become stubborn, not above, and the *arteries* become less, and if you squeeze the *veins*, unless you do so very strongly, hardly shall you see the blood pass above the *ligature*, or the *veins* swell.

So from these things it is easie for any man that will diligently observe, to know that the blood does enter by the *arteries*, and by their *strict ligature* nothing is attracted

tracted, the hand retains its colour, nor happens there any distension, but being little untied as in the *middle* or *gentle* *ligature*, it is manifest that the hand is swelled, and that the blood by the force and impulsion is abundantly thrust in. Where the blood flows forth as in the *gentle* *ligature* they beat, where it does not flow they beat not all. In the mean time the *veins* being streightned nothing can flow through them, of which this is a token, that beneath the *ligature* they become much more swelled, than above, and than they used to be when the *ligature* is taken away; hence it is clearly manifest, that the *ligature* hinders the return of the blood through the *veins* into the superiour parts, and makes those beneath the *ligature* continue swelled.

But the *arteries* in this case doe thrust out the blood beyond the *ligatures* from the inward parts by the strength and impulsion of the *heart*, notwithstanding the *gentle* *ligature*. This is the difference between the *strict* *ligature* from the *gentle* one, that the *strict* *ligature* does not only interceed the passage of the blood in the *veins* but the *arteries* also, that which is *gentle* does not hinder the pulsifick vertue, but that it stretches it self and drives out the blood into the furthest parts of the body.

So that we may reason thus; when in  
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*gentle ligature* we see the *veins* swell'd and distended, and the hand to be very full of blood, whence comes this? For either the blood comes through the *veins*, or through the *arteries* beneath the *ligature*, or through the hidden pores; Out of the *veins* it cannot, by hidden passages lesse, therefore needs must it by the *arteries*, as we have said. That it cannot by the *veins* is manifest, when the blood cannot be squeezed back above the *ligature*, unlesse you take the *ligature* quite away: Then you may see the *veins* fall and disburthen themselves into the upper parts, and the hand grow white, and all the formerly gathered swelling and blood to vanish away. He himself will better perceive it, whose body or arm has been so bound a good while, and his hands by that means come swell'd, and made colder; I say, shall feel somewhat that is cold to creep up to his elbow or armpits, to wit, with the return of the blood, which return of cold blood to the heart after blood-letting after the untying of the band, I did imagine to be the cause of fainting, which we likewise see come to passe in strong men, and most after the untying of the *ligature*, which commonly they say comes to passe from the turning of the blood. Besides, when presently upon the untying of the *strict ligature* into a *gentle* one, we see, that by the

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immiffion of blood through the *arteries*. the *veins* comprehended beneath the *ligature* do swell up, and not the *arteries*, is a figne that the blood does paffe out of the *arteries* into the *veins*, and not on the contrary; and that there is an *Anastomofis* of the veffels, or that the pores of the flefh and folid parts are pervious to the blood. It is likewise a figne that very many *veins* doe communicate together, when a gentle *ligature* being made about the arm many of them do fwel together, but paffage being open'd out of one little *vein* with the *Lancet*, they ftraightwayes fall all of them and difburthening themfelves all into that one, do almoft all flap down.

From hence may every body know the caufe of attractiō which is made by *ligatures* and perchance of all fluxes, *viz.* as in the hands, when the *veins* are drawn together by that *ligature* which I call *gentle*, the blood cannot go forth; in the mean time if it be driven violently through the *arteries*, that is to fay, by the force of the *heart* of neceffity the part muft be fill'd and diftended.

For otherwife how could it be? for *heat*, *anguish*, and force of the *vacuum* doe indeed attract, but fo as the part may be full, not that it fhould be diftended, and fwoln beyond its natural conftitution. But for the in-thruffing, and ftraight in-driving



og of the blood, it is neither to be beleevd  
 at can it be demon trated a member can  
 suddenly oppress'd. the flesh suffer a so-  
 on of its *continuum*, and the vessels be  
 to burst, that this can either be done  
 anguish, heat, or force of the *vacu-*

Moreover it so falls out, that there is an  
 traction made by the *ligature*, without  
 grief, heat, or force of the *vacuum*. But  
 y any *anguish* the blood should chance  
 be attracted, which way should, beneath  
*ligature*, the hands, and the fingers, and  
 ns swell. and become swell'd, the arm  
 ng tyed at the elbow, seeing that by rea-  
 of the compression of the *ligature* the  
 od could not come thither through the  
 ns? and why should there no signe ap-  
 r above the *ligature* either of *tumour* or  
*detumescence*, neither any signe of attraction or  
 flux at all?

But this is the manifest cause of attracti-  
 o beneath the *ligature*, and of swelling  
 beyond measure in the hand and fingers,  
 wit, that the blood does enter forci-  
 and apace, but cannot get out a-  
 n.

Hence is all the cause of *tumour*, and of  
 e-oppressive redundancie in any part;  
 cause the wayes of ingresse are open, and  
 wayes of regresse shut: hence it must  
 eds follow, that the *humour* should a-

E 2 bound,

bound, and the part be raised with swelling.

Whether may it not be from hence that in swellings which are inflam'd, so long as the swelling receives increase, and is in its highest estate, there is a full pulse in that place, especially in hotter *tumors* which the increase uses to be on a sudden shall be for our after-search; as likewise whether that happens from hence, (which by chance I had experience of in my self) I falling out of a Coach, and being for what hurt in my forehead, there where a little branch of the *arterie* creeps out of the temples, I felt a swelling about the bignesse of an egge in the space of twenty pulses without either heat or much pain, viz. because of the nearnesse of the *arterie*, the blood was abundantly and more swiftly driven into the bruiz'd place.

Hence does it appear for what cause *Phlebotomie* when we would have the blood leap out further and with greater force, bind it above the cutting of the *vein*, rather below; but if it flow in so great quantity through the *veins* from the superiour parts that *ligature* would not only not help, but hinder: for it were more likely that should be bound below, that the blood being hinder'd might goe out more abundantly if it did flow thither, and descend from the upper parts into the *veins*. H



the from somewhere else, it is driven by *arteries* into the lower *veins*, in which it passe by reason of the *ligature* is hindered, the *veins* swell and can squeeze it out, and throw it further through the *orifice*, but see, the *ligature* being untied, and a way of egress being open, the blood will no longer come, but drop by drop, that which every body knows, If in *Phlebotomie* you either untie the band, or bind below, or bind the member with too strict *ligature* it comes not forth, as if all force were taken from it, because forsooth the way of entrance and influx of blood through the *arteries* is by that strict *ligature* intercepted, or a more free reflux is granted through the *veins*, the *ligature* being untied.

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## C H A P. XII.

That there is a circulation of the blood, from the confirmation of the second supposition.

Being these things are so, it is certain that another thing which I said before is likewise confirm'd; that the blood does continually passe through the *heart*. For we see in the habit of the body, that the

blood flows continually out of the *arteries* into the *veins*, not out of the *veins* into the *arteries*: We see moreover, that from one arm the whole masse of blood may be exhausted, and that too by opening but one cuticular *vein* with a lance, if the *ligature* be handsomly made: We see besides, that it is powred out so forcibly, and so abundantly, that it is certain that not only that which was comprehended in the arm beneath the *ligature*, before the section, is quickly and in a little time evacuated, but likewise the blood out of the whole bodies as well the *veins* as the *arteries*.

Wherefore we must confesse first that by strength and force it is furnish'd, and by force it is driven beyond the *ligature* (for with force it goes out, and therefore by the strength and pulse of the *heart*) for the force and impulsion of the blood is only from the *heart*.

Next, that this flux comes from the *heart*, and that it flows by a passage made through the *heart* out of the great *veins*, seeing below the *ligature* the blood enters by the *arteries*, not by the *veins*, and the *arteries* at no time receive blood out of the *veins*, unlesse it be out of the *left ventricle* of the *heart*. Nor could there any other way so great abundance be exhausted out of one *vein*, making a *ligature* above, especially so forcibly, so abundantly, so easily.



so suddenly, unlesse the consequents  
be atchieved by the force and impulsion  
of the *heart*, as is said.

And if the *ie* things be so, we may very  
easily make a computation of the quanti-  
ty and argue concerning the motion of  
the blood. For if any one ( the blood brea-  
king out according to its usual effusion and  
force ) suffer it to come so for half an hour,  
no body needs doubt but that the greatest  
part of it being exhasted, faintings and  
convulsions would follow, and not only the  
*arteries*, but the greatest *veins* would be  
entirely emptied: Therefore it stands with  
reason, that in the space of that half hour  
there passes so much out of the great *vein*  
through the *heart* into the *aorta*. Further,  
you should reckon how many ounces  
pass through one arm, or how many ounce-  
s are thrust within the *gentle ligature* in  
about 30 pulsations, truly it would minister  
occasion of thinking how much may passe  
through the other arm, both the leggs, and  
through the *colufes*, and through all the other  
*arteries* and *veins* of the body: and that  
the flux which is made through the *lungs*  
and the *ventricles* of the *heart*, must con-  
tinually furnish of necessity new blood, and  
make a circuit about the *veins*, since so  
great a quantitie cannot be furnished from  
those things we eat, and that it is far grea-  
ter than is convenient for the nutrition of the  
parts.

It is to be observ'd further, that in the administration of *Phlebotomie* this truth chanceth sometime to be confirm'd; for though you tie the right arm, and lance it as it should be with a convenient *orifice*, and administer all things as they ought to be, Yet if fear, or any other cause, or sounding do intervene through passion of the mind, so that the *heart* doe beat more faintly, the blood will by no means pass through but drop after drop, especially if the *ligature* be made a little streighter. The reason is, because the pulse being but faint, and the outward driving force being but weak, the enfeebled part is not able to open the passages, and thrust out the blood beyond the *ligature*, yea nor to draw it through the *lunges*, or to remove it plentifully out of the *veins* into the *arteries*. So after the same manner does it come to pass that *Womens fluxes* and all other fluxes of blood are stop'd. This likewise appears by the contrary, for fear being remov'd, and the spirit recollected, when they do return to themselves, the *pulsifick strength* being now increased you shall streightway see the *arteries* beat more vehemently in that part where they are bound, and move in the *wrist*, and the blood leap out farther through the *orifice*.



## C H A P. XIII.

the third supposition is confirm'd, and that there is a circulation of the blood from the third supposition.

Hitherto concerning the quantitie of blood which passes through the *lungs* and *heart* in the centre of the body, and likewise from the *arteries* into the *veins* and habit of the body; It remains that we doe explain which way the blood flowes back from the extremities through the *veins* into the *heart*, and how the *veins* are the vessels that carry it from the extremities to the centre, by which means we think those three grounds propounded will be true, clear, firm, and sufficient to gain credit.

But this shall be plain enough from the *portals* which are found in the concavities of the *veins*, their use, and from ocular experiments.

The most famous *Hieron. Fabr. ab aqua* send. a most most learned Anatomist, and a venerable old man, or as the most learned *Riolanus* would have it, *Jac Silvius* did first of any delineate the membranal *portals* in the *veins* being in the figure of a *E*, or semilunarie, the most eminent and thinnest parts of the inward tunics of the *veins*: Their situation is in distant places, after a various manner, in diverse persons they

they are connate at the sides of the *veins* looking upwards towards the roots of them and in the middle capacity both of them (for they are for the most part two) looking towards one another, equally and duly touching one another, insomuch that they are apt to stick together at the extremities, and to be joynd; and lest they should hinder any thing to return from the roots of the *veins* into the little branches, or from the greater into the less, they are so plac'd that the horns of the hindmost are stretched towards the middles of the body of it which is before, and so interchangeable.

The finder out of these *portals* did not understand the use of them, nor others who have said lest the blood by its weight should fall downward: for there are in the *jugular vein* those that look downwards and doe hinder the blood to be carried upwards. I (as likewise others) have found in the *emulgent veins* and branches of the *Mesenteric*, those which did look towards the *vena cava*, and *vena porta*; add to this moreover that there are no such in the *arteries*, and it is to be observ'd that dogs and cattle have all their *portals* in the dividing of the *crural veins* at the beginning of the *os sacrum*, or in the *Iliac* branches near the *Coxendix*, in which there is no such thing to be feared by reason of the upright stature in man. Nor are their *portals* in the *jugulars*



*regulars*, as others say, for fear of *Apo-*  
*lexie*, because the matter is apt in sleep  
to flow into the head through the *soporall*  
*arteries*.

Nor that the blood may stand still in *di-*  
*varications*, and that the whole blood  
should not break in into the small branches  
or those which are more capacious: for they  
are likewise plac'd where there are no *di-*  
*varications*, though I confess they are more  
requent where *divarications* are.

Nor that the motion of the blood may  
be retarded from the centre of the body;  
for it is likely that it is thrust in leysurely e-  
nough of its own accord, out of the grea-  
ter into the lesser branches, and so that it  
is separated from the masse and fountain:  
But the portalls were meerly made, lest  
the blood should move from the *greater*  
*veins* into the *lesser* and tear or swel them;  
And that it should not goe from the centre  
of the body to the extremities, but rather  
from the extremities to the centre. There-  
fore by this motion the *small Portals* are ea-  
sily shut, and hinder any thing which is  
contrary to them; for they are so plac'd  
and ordain'd, that if any thing should not  
be sufficiently hindred in the passage by  
the *hornes* of the formost, but should escape  
as it were through a chinck, the convexi-  
ty or vault of the next might receive it, and  
so hinder it from passing any further.

I have often tried that in dissection if beginning at the roots of the *veins* I did put in the *Probe* towards the small branchess with all the skill I could, that it could not be further driven by reason of the hindrance of the *Portalls*: On the contrary, if I did put it in outwardly from the branchess towards the root, it passed very easily. In many places two *portalls* are so interchangeably plac'd and fitted, that when they are elevated in the middle of the concavity of the *vein*, they close with one another too a hairs bredth, and in their extremitiess and convexities are united interchangeably that you can neither see with your eyesight nor any way discern any crevice or conjunction: on the contrary from outwardly putting in a *Probe* they easily give way, (and like those gates or sluices by which the course of rivers is stopt) they are easily turn'd back to intercept the motion of the blood from the *vena cava* and the *heart*, and being closely lifted up in many places whilst they are interchangeably shut they doe quite hinder and suppress, nor by any means suffer the blood to move neither upwards to the head nor downwards to the feet, nor to the sides or arms, but do stop and resist all manner of motion of the blood, which is begun in the *greater veins* and ends in the *lesser*, yet doe obey any which is begun by



by the *small veins* and ends in the *greater*,  
and does provide a free and open way for

But that this truth may the more clearly  
appear, let the arm of a man alive be ti-  
ed above the Elbow, as if it were to let  
blood, A A will appear at distance espe-  
cially in country people and those who are  
swoln vein'd, like little nodes, or swellings:  
And B C D E F not only where the *diva-*  
*gation* is E F, but likewise where there is  
one C D, and these nodes are made by the  
*portals*. They thus appearing in the inside  
of the hand or cubite, if you draw down  
the blood with your thumb or finger from  
the node O to H in the second figure, you  
shall see that none can follow (the *portal*  
quite hindring it) and that the part of the  
*vein* H O of the second figure, drawn  
down betwixt the swelling and the finger,  
quite obliterated, and yet full enough  
above the knot or *portal* O H: Nay if you  
retain the blood so drove down and the  
blood emptied H, and do press downward  
with tother hand the upper part of the *vein*  
, in the third figure, being full, you  
shall find that by no means it can be forc'd  
or driven beyond the *portal* O; But how  
much more you do endeavour to do this,  
so much the more shall you see at the *portal*  
or swelling of O, of the third, the *vein*  
swoln and distended, and yet that H O of  
the

the third figure is empty below.

Hence, since a man may make experiment in many places, it appears that the function of the *portall* in the *veins* is the same as that of the *Sigmoides*, or three pointed *portals*, which are made in the *co* *ri* *fice* of the *aorta* or *vena arteriosa*, to wit that they may be closely shut up, lest they should hinder the blood to return back again.

Besides tying the arm again as before A A, and the *veins* swelling, if you hold the *vein* below any swelling or *portal* at any distance L of the fourth, and afterwards with your finger M drive the blood upwards above the *portal* N, you shall see that part of the *vein* L N to remain empty and that it cannot return by reason of the *portall* H O 2. but taking away your finger H 3. or L in the fourth figure, you shall see't again fill'd by the lower *veins* and be like D C of the 1. so that from hence it appears plainly, that the blood does move towards the upper parts and the heart in the *veins*, and not on the contrary; and albeit in some places which are not closely shut, or where there is but one *portal*, the passage of the blood from the centre seems not to be quite hindred, yet for the most part it appears so, or at least that which is negligently perform'd in some places is recompens'd by the *portals*, in or

dec



or following, either through their number, vigence, or some other way, insomuch as the *veins* are the open and patent wayes of turning the blood to the *heart*, but quite stop'd in its going out from thence.

This is moreover to be observ'd, tying the arm as before, and the *veins* swelling, and nodes or *Portals* appearing, if below any *Portal* in any place where you find the next you place your finger, which may hold the *vein*, that no blood may goe from your hand upwards, then squeeze with your finger the blood from that part of the *vein* L above the *Portal* as was said before, then taking away your finger L suffer it to be held up by those under, as D C, and then pressing again with your thumb in the same place, squeeze out the blood L N and H and do this a thousand times in a little space.

Now if you reckon the businesse, how much by one compression moves upwards suppression of the *portal*, and multiply that by thousands, you shall find so much blood pass'd by this means through a small part of a *vein*, that you will find your self perfectly perswaded concerning the circulation of the blood, and of its swift motion.

But lest you should say, that by this means Nature is forc'd, if you doe this in *veins* farre distant, and doe observe, taking

king away your thumb, how soon, and how swiftly the blood returns and fills the lower part of the *vein*, I doe not doubt but you will find the very same.

#### C H A P. XIV.

*The Conclusion of the demonstration of the circulation of the blood.*

**N**OW then in the last place we may bring our opinion, concerning the *circulation of the blood*, and propound it to all men.

Seeing it is confirm'd by *reasons* and *ocular experiments*, that the blood does pass through the *lungs* and *heart* by the pulse of the *ventricles*, and is driven in and sent into the whole body, and does creep into the *veins* and porosities of the flesh, and through them returns from the little *veins* into the greater, from the circumference to the centre, from whence it comes at last into the *vena cava*, and into the *ear* of the *heart* in so great abundance, with so great flux, and reflux, from hence through the *arteries* thither, from thence through the *veins* hither back again, so that it cannot be furnished by those things which we do take in, and in a far greater abundance than



incompetent for nourishment: It must be  
necessity concluded that the blood is driven  
into a round by a *circular motion* in  
veins, and that it moves perpetually;  
and hence does arise the action and function  
of the *heart*, which by pulsation it  
performs; and lastly, that the motion  
and pulsation of the *heart* is the only  
use.

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C H A P. XV.

*The circulation of the blood is confirm'd by  
probable reasons.*

Ut it will not be amiss likewise to add  
this, that according to some common  
persons it is convenient, and it ought to be  
First (*Arist. de respir. & lib. 2. 3. of the  
parts of creatures*) seeing death is a corrup-  
tion which befalls by reason of the defect  
of heat, and all things which are hot being  
cold, are cold when they die, there must  
be a place and beginning of heat, (as  
were a Fire, and dwelling house) by  
which the nursery of Nature, and the first  
beginnings of inbred fire may be contain'd  
preserv'd; from whence heat and life  
flow, as from their beginnings, into all  
parts; whither the aliment of it should  
F come,

come, and on which all *nutrition* and *vegetation* should depend.

And that this place is the *heart*, from whence is the beginning of life, I would have no body to doubt.

There is therefore a motion requir'd to the blood, and such a one as that it may return again to the *heart*; for being sent far away into the outward parts of the body (as *Arist. 12 part. de Anim.*) from its own fountain, it would congeal and be immovable. (For we doe see, that by *motion*, *heat* and *spirit* is ingender'd, and preserved in all things and by want of it vanishes) Seeing therefore, that the blood staying in the outward parts is congealed by the cold of the extremities, and of the ambient air, and is destitute of *spirits*, it is in dead things, it was needfull it should resume and redintegrate, by its return again, as well heats, as spirit, and indeed its own preservation, from its own fountain and beginning.

We see, that by the exterior cold, the extremities are sometimes chill, insomuch as nose, hands, and cheeks, doe look bleaish like those of dead men, because that the blood stands still in them, (as it does in carkasses in those parts which are down retarding,) whence it comes, that the members are numm'd, and hardly moveable, so that they seem quite almost to have lost life.

Th



they could certainly by no means (especially so soon) recover heat, and colour, and life, unless they were by a new original, a Flux, and appulsion of heat, again cherish'd. For how can they attract in whom heat and life are almost extinct? or those that have their passages condens'd all stopt with congeal'd blood, how could they receive the coming nourishment and blood unless they did dismiss that which they before contain'd, and unless the *heart* were really that beginning from whence heat and life (as *Arist. respicit. 2.*) and from whence new blood be-passed through the *arteries* imbued with spirit, that which is enfeebled and cold might be driven out, and all the parts might redintegrate their languishing heat and vital nourishment almost extinct? Hence it is that it may come to passe, that the *heart* being untouch'd, life may be borrow'd to the rest of the parts, and soundness recover'd; but the *heart* being refrigerated or affected with some heavy disease, the whole *animal* must needs suffer, fall to corruption. When the beginning is corrupted, (as *Arist. 3 de part. Anim.*) there is nothing which can afford help to the rest of those things which do depend upon

And hence perchance the reason may  
be drawn, why in those that with grief,  
F 2 love,

love, cares, and the like are possessed, a consumption or continuation happens, or cacochymie, or abundance of crudities which cause all diseases and kill men. For every passion of the mind which troubles mens spirits, either with grief, joy, hope or anxiety, and gets access to the heart there makes it to change from its naturall constitution, by distemperatures, pulsation, and the rest, that infecting the nourishment, and weakning the strength, it ought not at all to seem wonderfull if it afterwards beget divers sorts of incurable diseases, in the members, and in the body, seeing the whole body that case is afflicted by the corruption of the nourishment, and defect of the nutritive warmth.

Besides all this, seeing all creatures live by nourishment inwardly concocted, it is necessary that the concoction and distribution be perfect, and for that cause the place and receptacle where the nourishment is perfected, and from whence it is deriv'd to every member. But this place is the heart, since it alone of all the parts (though it has for its private use the *coronary vein* and *arterie*) does contain in its concavities, as in cisterns, or a cellar, (with *ears* or *ventricles*) blood for the public use of the body; but the rest of the parts have it only in vessels for their own



shoe, and for private use. Besides, the  
 heart only is so plac'd and appointed, that  
 from thence by its pulse it may equallie di-  
 tribute and dispence ( and that according  
 to measure, and the concavities of the arte-  
 ries, which are to supply every part ) to  
 the whole which want, and deal it after this  
 manner, as out of a treasure and fountain.  
 Moreover to this distribution and motion  
 of the blood, violence, and an impulsor is  
 requir'd, such as the heart is. To this add,  
 that the blood does easily concentrate,  
 and joyn of its own accord, to its begin-  
 ning, as a part to the whole, or as a drop  
 of water spilt upon the table to the whole  
 masse, as it does very swiftly, for slender  
 causes, such as are cold, fear, horror,  
 and the like. Besides, it is squeez'd out of  
 the capular veins into the little branches,  
 and from thence into the greater, by the  
 motion of the members, and muscles: Like-  
 wise the blood is apter to move from the  
 circumference to the centre, than otherwise  
 though the portals did not hinder. From  
 hence it follows, that if it do leave its  
 beginning, and move against its will, and  
 enter into places narrower, and colder,  
 that it has need of violence and an impul-  
 sor, such is the heart only, as we said but  
 now.

## C H A P. XVI.

*The circulation of the blood is prov'd by consequence.*

**T**Here are likewise Questions, which from this supposed verity, for creating of belief, as arguments *à postérieure*, are not altogether unusefull. These though they be envelop'd in much doubtfullness and obscurity, yet easily admit of the assignation of causes and reasons.

We see in contagion, in poison'd wounds, or in the bitings of *Serpents*, or *mad doggs*, in the *French Pox*, and the like, that the part touch'd being not hurt it so falls out that the whole habit of the body is vitiated. The *French Pox* sometimes bewrayes it self by the pain of the head, or the shoulders, or other Symptoms the genitals having no hurt at all. The wound made by the biting of a *mad dog*, being cured, we have notwithstanding observed, that a *feaver*, and other horrible Symtoms have ensued: Because the contagion being imprinted into the part, it appears, that it is from hence carried to the *heart* with the blood returning, and afterwards infect the whole body. In the beginning of a *tertian feaver* the morbid sick cause going to the *heart* makes the breath



breathlesse, sighing, and lazie, because the vital beginning is oppressed, and the blood is driven against the *lungs*, and thickned, and finds no passage (I speak this, having had experience from the dissection of them that have dyed in the beginning of the accession) then the pulsations are always frequent, little, and sometimes disorderly: But the heat being increased, and the matter obtenuated, the wayes being open, and passages made, the whole body grows hot, the pulses become greater and more vehement, the proximum of the *feaver* growing higher, wit, the preternatural heat being kindled in the *heart*, is diffus'd from thence by the *arteries* into the whole body, together with the morbifick matter, which by this means is overcome and dissolved by nature.

Likewise, seeing medicaments outwardly applied, ever use their force within, as they were taken inwardly: (*Coloquintida* and *Aloes* loosen the bellie; *Garlick* applyed to the soles of the feet, causes excretion; *Cantharides* move urine, and *diacials* doe corroborate, and infinite of this kind.) From hence it is constantly arriv'd, perchance not without cause, that the *veins*, through their *orifices*, draw a quantity of those things which are outwardly applyed, and carry it in with the blood,

after the same manner as those in the *Mesenterie* do suck the *Chylus* out of the *intestines*, and carry it to the *liver*, together with the blood.

In the *Mesenterie* likewise, the blood entering into the *Cœliac arterie*, the upper and neither *Mesenteries*, goes forward to the *intestines*; by which, together with the *Chylus* attracted by the *veins*, it returns through the many branches of them into the *Porta* of the *liver*, and through it into the *venacava*; so it comes to passe that the blood in these *veins* is imbued with the same colour and consistence, as in the rest, otherwise than many believe for we must needs believe, that it verifitly and probably comes to passe, in this stemme or branch of the *capular veins* that there are two motions, one of the *Chylus* upwards, another of the blood downwards; but is not this done by main providence of nature? for if the *Chylus* should be mix'd with the concocted blood in equall proportions, no concoction, transmutation, or sanguification should from thence arise: But rather since they are interchangeably active and passive, from the union of them being altered, there should arise a mixture, and something of a middle nature betwixt the two as in the mixing of wine and water, there is begotten a wine-foyl: But now, where

will



With the great quantity of blood which  
passes by, a part of the *Chylus* is mix'd  
in this manner, and as it were in no re-  
markable proportion, that doth (as *A-*  
*stotle* sayes) more easily come to passe;  
when one drop of water is put into a  
hoghead of wine, or on the contra-  
ry, the whole is not mixed, but it is  
either wine or water; so in the *Mes-*  
*enterick veins*, being dissected, there is  
found a *Chymus*, not the *Chylus* and  
blood a part, but mixed, and the same both  
colour and consistence to the sense, as  
appears in the rest of the *veins*; in which  
notwithstanding, because there is some-  
thing of the *Chylus* inconcocted, although  
insensible, Nature hath placed the *liver*,  
in the *Meanders* or crooks of which it is  
delay'd, and receives a fuller transmuta-  
tion, lest coming too soon raw to the  
heart, it should overwhelm the beginning  
of life. Hence in *Embryons* there is no  
use of the *liver* where the *Umbilical vein*  
both apparently passe through the whole,  
or there stands out of the *porta* of the *liver*  
*hole* or *Anastomosis*, that the blood  
returning from the *intestins* of the birth,  
passing not through the *liver*, but the  
forementioned *Umbilical vein*, might go to  
the heart, together with the mothers blood  
returning from the *Placenta* of the womb;  
from whence likewise, in the first forming  
of

of the birth, it comes to passe, that the *liver* is made last. We likewise in a woman's untimely birth, have observ'd all the members shap'd, the *Genitals* distinctly, and yet scarce any foundation of the *liver* to have been laid. And truly so long as these members (as likewise the *heart* it self in the beginning) are all whole, and that there is no rednesse conteyn'd in the *veins*, you shall see nothing but a rude collection as it were of blood, without the vessels, instead of the *liver*, which you would think to be some bruse or broken *veines*.

There are in a *Egg* as it were two *Umbilical* vessels, one passing through the whole *liver*, from the *white*, and going directly to the *heart*; the other going from the *yolk*, and ending in the *vena porta*. For so it is, that a *Chick* is first onely nourished and found by the *white*, and afterwards by the *yolk*, after its perfection and exclusion; for the *yolk* may be found to be contain'd in the belly of the *Chick* many dayes after the hatching, and it is answerable to the nourishing of milk in other creatures. But we shall speak of these things more conveniently in our observations concerning the forming of *births*, where there may be many enquiries of this nature, why this is first made and perfected, and that afterwards; and of the principa-  
litie



tie of Members, what part is the cause of another ; and many things likewise concerning the *heart* , As why ( as *Arist. de art. Anim. 3.* ) it was made the first consistent, and seems to have in it life , motion, and sense, before any thing of the rest of the body be perfected ; And likewise of the blood, why before all things, and how it has in it the beginning of life, and of the creature; why it requires to be mov'd and driven up and down; and then for what cause the *heart* seems to have been made.

After the same manner in the speculation of pulses, to wit, why such are deadly, others not ; and in all kinds by contemplation of their causes and prelages, what those signifie, and what these , and why.

Likewise in the *crisises* and *expurgations* of Nature; in nutrition, especially in distribution of the nutriment ; and likewise in all fluxions, &c.

Lastly, in all parts of *Physick*, *Physiologicall*, *Pathological*, *Semeiotick*, *Therapeutick*, when I do consider with my self how many questions may be determined, this truth and light being given ; how many doubts may be solved, how many obscure things made clear , I find a most large field, where I might run out so far, and enlarge my self so much, that it would not en-

only swell into a great volume, which is not my intention, but even my life-time would be too short to make an end of it.

Therefore in this place, that is to say, in the following Chapter, I shall onely endeavour to refer those things to their proper uses, and causes, which doe appear in the administration of *Anatomie*, about the *fabrick* of the *heart*, and *arteries*: for there where I intend to addresse my self, very many things are found which receive light from this truth, and do in return make it more clear, which I desire to adorn, and confirm by *Anatomical* arguments, beyond all the rest.

There is one thing, which although it ought to have place too in our observation concerning the use of the *Milt*, yet will it not be impertinent to take notice of it here by the by.

From the *splenick veins* drawn down into the *Pancreas*, there arise *veins* from the upper part of it: the *Coronall*, *Postick*, *Gastrick*, and *Gastroepiploick*; all of which with very many *branches* and *tendons*, are dispers'd into the *ventricle*, as the *mesentericks* are into the *intestines*. Likewise from the inferior part of this *splenick*, down as far as the *Colon* and *Longanon*, the *Hæmorrhoidal vein* is deducted. The blood returning through those *veins* by both ways



ayes, and carrying the rawest juice with  
 ( hence from the *ventricle*, that which  
 waterish and thin, the chilification being  
 not as yet perfected; from thence that  
 which is grosse and terrestriall ) in this  
 branch of the *splenick*, by the permixtion  
 of contraries, it is conveniently temper'd;  
 and Nature mixing those two juices of  
 more difficult concoction, by reason of their  
 contrary indispositions, with great abun-  
 dance of warm blood, which ( by reason  
 of the abundance of *arteries* ) flows abun-  
 dantly from the *milt*, it brings them, be-  
 ing now better prepar'd, to the *porta* of the  
*liver*, and supplies and recompences the  
 defect of both by such a structure of the  
*veins*.

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## C H A P. XVII.

*The motion and circulation of the blood is  
 confirm'd by those things which appear in  
 the heart, and from those things which  
 appear in Anatomical dissection.*

Doe not find the *heart* in all creatures  
 to be a distinct and separate part; for  
 some, as you would say *Plant animals*, have  
 no *heart*; Colder creatures of a softer  
 make, and of a kind of similarie constituti-  
 on,

on, such as are *Palmer-worms*, and *Snails*, and very many things which are ingendered of putrefaction, and keep not a *species*, have no *heart*, as needing no impulſor to drivee the nutriment into the *extremities*: Forr they have a body *connate* and of one piece, and indistinct without members; so thatt by the contraction and returning of their whole bodie, they take in, expell, movee and remove the nourishment, being call'd *Plant animals*; such as are *Oysters*, *Musſles*, *Sponges*, and all sorts of *Zoophyts*, have no *heart*; for instead thereof they use their whole body, and this whole creature is as a *heart*.

In very many, and almost all kinds of *Insects*, by reason of the smallnesse of their *Corpulency*, we cannot rightly discern; yet in *Bees*, *flies* and *wasps* we may by the helpe of a perspective glasse. You may likewise see something beat in *lice*, in which moreover you may clearly see the passage of the nourishment through the *intestines* (this Animal being transparent) like a black spot, by help of this multiplying glasse. But in those that have no blood and are colder, as in *Snails*, *Shell fish*, *Crusted-Shrimps*, and the like, there is a little part which beats (like a *little bladder*; or an *ear*) without a *heart*, making its contraction and pulse seldomer, and such a one as you cannot discern but in summer, or in a hot season.



In these creatures this particle is ordain'd so, that there is a necessity of some impulsion for the distribution of the nourishment, by reason of the variety of the *or-  
gick* parts, or the thicknesse of their substance: but the pulsations are made *adom*er, sometimes not at all, by reason of their coldnesses, as it it meetest for them, being of a doubtfull nature, so that sometimes they seem to live, sometimes to die, and sometimes to live the life of an *ani-  
mal*, sometimes the life of a *Plant*.

This is likewise contingent to those *In-  
sects* which doe lurk in the Winter, and are as if they were dead, and do only lead the life of a *Plant*; but whether this doe likewise happen to some creatures that have blood, as to *Frogs*, *Snayls*, *Ser-  
pents*, *Swallowes*, we may not without reason make a question.

In creatures which are a little bigger, and hotter, as having blood in them, there is an impulsion of the nutriment requir'd, such a one perchance as is endued with more force; therefore in *Fishes*, *Serpents*, *Snakes*, *Snails*, *Frogs*, and others of the same nature, there is both one *ear*, and one *ventricle* of the *heart* allotted, whence rise that most true Axiom of *Arist. de part. anim.* 3. That no creature having blood does want a *heart*, by the impulsion of which it is made stronger and more robust, and

and the nutriment is not only stirr'd up  
and down by the *ear*, but likewise is thrust  
out further and more swiftly.

That in creatures yet greater, hotter  
and more perfect, (as abounding with  
great deal of hotter blood, and full of spirit)  
there is a stronger and more fleshie  
*heart* requir'd, that the more strongly, more  
swiftly, or with greater force the nutriment  
may be thrust out, by reason of the  
bignesse of the bodie, and thicknesse of  
the habit.

And moreover, because that more perfect  
creatures need more perfect aliment  
and a more abundant native heat, that the  
nutriment of them may be concocted, and  
acquire a further perfection, it was fit that  
these creatures should have *lungs*, and another  
*ventricle*, which should drive the nutriment  
through them.

So in whatsoever creature there  
*lungs*, there is likewise in them two *ventricles*  
of the *heart*, the *right*, and the *left*  
and wheresoever the *right ear* is in an  
there is the *left*, not on the contrary, that  
where the *left* is, there is the *right* one too  
that I call the *left ventricle* which is distinguished  
in place, but not in use from the  
tother, which doth diffuse the blood into  
to the whole bodie, not into the *lungs*  
alone, hence the *left ventricle* seems  
make up the *heart* of it self, being placed



the middle, and so fenc'd with higher dit-  
tines, and fram'd with greater diligence,  
that the heart seems to have been made for  
the *left ventricle's* sake, and the *right*  
*ventricle* seems as it were a servant to the  
*left*, and does not reach to the top of it,  
and is made up of a thinner threefold wall,  
and it has, as *Aristotle* says, a kind of ar-  
ticular above the *left*, and is more capa-  
cious, as administering not only matter to  
the *left*, but giving nourishment likewise  
to the *lungs*.

But it is to be observ'd in *Embryons*.  
These are far otherwise, and that there is  
such great difference of the *ventricles*,  
like two kernels in a nut they are al-  
most equall, the corner of the right reaches  
to top of the left, so that in them the  
*left* hath as it were a double top at the  
front. These things come to passe because  
in them whilst the blood does not passe  
through the *lungs*, as it does passe  
from the *right bosome* of the heart to the  
*left*, both the *ventricles* do perform alike  
office, bringing the blood through  
in the *vena cava* into the *arteria magna*  
that ovall hole and arterious passage, as  
has been said, and do equally divide it  
to the whole body, whence proceeds  
an equal constitution. But when it is time  
the *lungs* should be used, and the  
said unions begin to be stop'd, then  
G does

does this difference of *ventricles* begin to be in their strength, as likewise in the rest because the *right* drives only through the *lungs*, the left through the whole body...

There are besides these in the *heart* also *tendons*, as I may so say, or fleshy twiggies and very many *fibrous connexions*, which *Arist.* in his book *de respir.* and *de part. anim.* 3. calls *nerves*, of which some appear to be stretch'd with divers motions, and are partly hidden in furrows with deep dissections about them in the walls and *mediastinum*, & they are like a kind of little *muscles* which are underordained, and superadded to the *heart*, as auxiliaries, for the further expulsion of blood, that like the diligent and artificial provision of tackling in a ship, they might help the *heart* contracting it self every way, and might squeeze out the blood more fully and forcibly out of the *ventricles*.

And this is manifest from hence, because some *animals* have them, some not, and all which have them are stronger in the *left ventricle* than in the *right*; some *animals* have them in the *left*, and not at all in the *right*, in men there are more of them in the *left* than in the *right*, and more in the *ventricles* than in the *ears*, and in some *ears* almost none; there are more of them in brawny, muscular and ruxall bodies, and such as are of rough



abit of body, than in those which are  
nder, and in women there are few-

In those creatures in which the *ventri-*  
is within are smooth, altogether with-  
at *fibers* and *tendons*, and which are  
it cleft into ditches (as almost in all little  
ids, *Serpents*, *Frogs*, *Snails*, and the  
le, in the *Partridge* likewise and the *Hen*,  
all the greatest part of *Fishes*) in them  
rather those *nervus* or *fibers* mentioned,  
the *three-fork'd portals* are to be found  
the *ventricles*. In some *animals* the *right*  
*ventricle* is smooth within, the *left* has  
se *fibrous* connexions, as in the *Goose*,  
*Duck*, and greater birds: In them the  
e cause is alleged as in all, seeing  
the *lungs* are spongy & soft they need  
uch force to impell the blood through  
in; therefore in the *right ventricle* ei-  
they have no *fibers*, or els fewer and  
ker, nor are so fleshy and compara-  
to *Muscles*, but in the *left* they are  
nger and more in number, more fleshy  
musculous, because the *left ventricle*  
a need of more strength and force, by  
on that it ought to pursue the blood  
ner through the whole body.

From hence it is likewise, that the  
*ventricle* possesses the middle of the  
t, and hath a wall threefold thicker,  
is stronger than the *right ventricle*.

Hence all creatures, men likewise, by how much the habit of their flesh is harder and more solid, and by how much more their outward members are more fleshy, and farthest from the heart, and brawnier, so much more fibrous, thicker, robust, and musculous a heart have they; and this is necessary and clear; on the contrary, by how much the more they are fine-spun, of a softer habit, and of slenderer bodies, so much the softer, flaggier, and less fibrous heart within (or not at all) have they.

Likewise consider the use of the *portals* which were made for that cause, lest the blood once let out should be returned to the heart, and as well in the *orifice* of the *arterie*, as of a *vein*, they are up lifted and enterchangeably joyned, they make a three square line, such as is imprinted in the biting of a *Swallow*, that being shut more closely they may hinder the reflux blood.

There are three forked *portals* in the entry of the *vena cava*, and *arteria venosa*, lest that when the blood is most driven out should fall back, and for that cause they are not in all creatures, & in those in which they are, they do not seem to be made with the same diligence of nature, but in some they are shut more exactly, in others more carelessly and negligently; therefore



In the *left ventricle*, that for the greater impulsion there may be a closer stoppage, there are only two like a Mitre, having tendons reaching out far, even to the *conus* of it, through it middle, that they may be most exactly shut. This perchance deceived *Aristotle*, in making him believe that this *ventricle* was double, the division being made athwart, lest the blood should fall back again into the *arterie*, and by that means the strength of the *left ventricle* in driving forth the blood into the whole body should be destroyed, therefore these *portals* do much surpasse in bignesse, strength, and exact shutting, those which are placed in the *right*. Hence likewise of necessity, no *heart* is seen without a *ventricle*, since it ought to be the well-spring, fountain, and cellar of blood. The same does not always happen in the *brain*; for almost all sorts of birds have no *ventricle* in the *brain*, as it appears in the *Goose* and *Swan*, the *brains* of these, although the *brains* of a *Conie* be almost as big, yet the *Conie* hath *ventricles* in the *brain*, the *Goose* has not.

Likewise, wherever there is one *ventricle*, there hangs by it an *ear* flagging, cuticular, hollow within, full of blood; where there are two *ventricles*, there are likewise two *ears*; on the contrary, there is only one *ear* in some creatures, or at

least a *bladder* answerable to an *ear*, over the *vein* it self dilated ( but not the *ventricle* of the heart ) making a pulse instead of the *heart*, as it appears in *Hornets*, *Bees*, and other *Insects*, whom I believe I cannot demonstrate by some experiments, to have not only a pulse, but a respiration likewise in that place which they call the tail : whence it happens that it is lengthned and contracted, sometimes oftner, sometimes more seldome, according as they seem more panting or to be more indigent on air : but of this in the treatise of *Respiration*. It is likewise manifest that the *ears* do beat and contract themselves, as I said before, and cast the blood into the *ventricle* whence it is, that wheresoever there is a *ventricle* there an *ear* is requir'd not only ( as is commonly believ'd ) that it may be the receptacle and cellar of blood, ( for what needs there any pulsation for the retaining of it? ) but the first movers of the blood are the *ears*, especially the *right* being the first thing that lives, and the last that dies, as before is said ; for which cause they are necessary, that they may serve to poure the blood into the *ventricle*. But the *ventricle* immediately contracting it self, doth more conveniently squeeze out, and more violently thrust forth the blood, being already in motion ; as when you play at ball, you can strik



farther, and more strongly, taking it a  
*vole*, than you could only throwing it  
 out of your hand. But likewise, contra-  
 ry to the vulgar opinion, because neither  
 the *heart*, nor any thing else can so ex-  
 tend it self as that it can attract any thing  
 at its diastole (unlesse in its return to its  
 former constitution, being before squee-  
 zed like a sponge, ) but it is certain,  
 that all local motion comes first, and did  
 have its beginning, from the contraction  
 of some particle; therefore by the con-  
 traction of the *eares*, the blood is cast into  
 the *ventricles* as I open'd before, and by  
 the contraction of the *ventricles*, its  
 driven farther and remov'd.

Which truth concerning locall motion,  
 is that the immediate *motive organ* (in  
 creatures in which a motive spirit is  
 primarily ) is contractible, as *Arist.*  
 writes in his book *de spirat.* and elsewhere,  
 that *Aristotle* did know the *muscles*  
 when he did refer all the pains and moti-  
 ons in creatures to the *nerves*, or that  
 which is contractable, and therefore  
 and those *tendons* in the *heart*, *nerves*;  
 I hope it shall be made clear if at any  
 time I shall have liberty to demonstrate  
 concerning the *motive organs* of creatures,  
 the fabrick of the *muscles*, from my  
 own observations.

But pursuing our purpose concerning

the use of the *ears*, which we did demonstrate was to fill the *ventricles* with blood, we see it comes to passe, that the thick and more compact the *heart* is, and of a grosser wall, the more *nervous* and *muscularous* the *ears* are to draw in and fill in, and in those in whom they are contrarywise, it does appear in them as a bladder of blood, or a membrane conteyning blood, as in fishes, for there the bladder which is in lieu of the *ear* is very thin and so large that the *heart* seems to swim above it; but in those fishes in which the bladder is a little more fleshie, it seems very precisely to emulate and counterfeite the *lungs*, as in the *Barbell*, *Tench*, and others.

In some men, to wit such as are brave, and of a rougher habit of body, we have found the *right ear* so strong and neatly made up within, with the various contexture of *fibers*, that it did seem to be equall in strength to the *ventricles* in other men; and truly I did wonder that in divers men there should be such difference. But it is to be observ'd, that at the birth the *ears* are farre greater in proportion, because before the *heart* is made, that it may do its own function (as before was shew'd) they do the office of the *heart*.

But the things that I observ'd concern



ing the forming of the birth which I made  
ation of before, and *Aristotle* confirms  
an egg, doe adde a great deal of credit  
rt light to this businesse; first, whilst the  
his as it were a tender worm, and  
hilst it is yet (as is usually spoken) in the  
ilk, there is in it a little *bladder* or *bag*  
hich beats, and as it were a portion of  
e *umbilical vein*; afterwards, when the  
rth being shaped, begins to have a  
stronger corpulency, this little *bag* be-  
oming more fleshie and robust (changing  
constitution) turns into *ears*, above  
hich the body of the *heart* begins to  
ring, as yet executing no publick office;  
t the birth, when tis already form'd,  
d that the bones are distinct from the  
sh, and it is a perfect creature, and  
at it is felt to have motion, then the  
art is both found beating within, and  
es transfuse the blood as I have said out  
the *vena* into the *arterie* through both  
e *ventricles*.

So Nature being perfect and divine, and  
aking nothing in vain, neither gave a  
art to any where there was no need,  
r made it before there was any use for  
but by the same degrees in the for-  
ing of all *animals* passing through the  
stitutions of all creatures (as I may  
in the egg, *Worm*, and birth) it acquires  
perfection in them all. These things  
shall

shall be confirm'd elsewhere by many observations in the forming of the birth.

Lastly, *Hippoc.* in his book *de Cord.* didd not without reason call it a *muscle*, seeing the action and function of both is the same, viz. to contract it self, and move somewhat else, that is the blood.

Moreover, from the constitution of the *fibers*, and their motive frame, as likewise in the *muscles*, we may see the action and use of the heart. All Anatomists have observ'd with *Galen*, that the body of the *heart* is made with severall draughts of *fibers* streight, thwart, and crooked, but in a *heart*, being boy'd the structure of the *fibers* it found to be otherways.

For all the *fibers* in the walls and in the inclosure are circular, as they are in a *Sphincter*, but those which are in the *tendons* stretched out in length, are crooked; so it comes to passe that when all the *fibers* are contracted, it happens that the top is brought to the bottom by the *tendons*, and the walls are inclosed in a round, and the *heart* is contracted every way, and the *ventricles* strengthned. Wherefore since the action of it is contraction, we must need imagin that the function of it is to thrul blood out into the *arteries*.

Nor must we disagree from *Aristott* concerning the principality of the *heart* and that it does not receive motion and

sent



ise from the *brain*, nor blood from the *liver*, but that is the beginning of the *veins*, all of the blood, and the like; Seeing also that endeavour to confute him omit the chief argument, to wit, That the *heart* is the first subsistent, and that it hath blood, sense and motion before the *brain* or *liver* were made, or appear'd distinctly, at least before they could perform any function. To this adde, That the *heart*, as a main internal *animal*, consists longer, as a creature by the making of this first, would be the whole *animal* afterwards to be nourish'd, preserv'd, perfected by it as its own work and dwelling place. The *heart* is as it were a Prince in the Commonwealth, in whose person is the first and chief government every where; from whence, as from the original and foundation, all power in the *animal* is deriv'd, and all depend.

But besides very many things about the *veins* doe likewise evidence and confirm the truth; When it is consider'd why the *vena venosa* does not beat, since it is num- ber'd amongst the *arteries*; or why there is no pulse found in *vena arteriosa*, since the pulse of the *arteries* arises from the impulse of blood; or that the *arteries* in the thickness of their *tunics*, and the strength of them, do differ so much from the *veins*, that they bear the force of the impulsi- on

on of the *heart*, and breaking out of the blood.

Hence, since Nature who is perfect makes nothing in vain, and is sufficient to all things, the nearer the *arteries* are to the *heart*, the more they differ from the *veins* in their constitution, and are more robust and full of ligaments, but in the furthest dispersions of them, in the *hand*, *foot*, *brain*, *mesenterie*, and *spermatick vessels*, they are so like in their constitution that earnestly viewing their *tunics*, it is a hard businesse to know one from the other.

And this is so for just causes. For the further the *arteries* are distant from the *heart*, by so much lesse strength a great deal are they struck, the stroak of the *heart* being weakned by the great distance. Adde to this, that the impulsions of the *heart*, since it must needs be sufficient in the trunks and branches of the *arteries*, is lessen'd at every partition, as being divided, insomuch that the last divisions of the *capillares; arteriosae* seem to be *veins*, only in constitution, but likewise in function, or do not give a sensible pulse, none at all, or else not alwayes, unless the *heart* doe beat more forcibly, or if a little *arterie* be dilated, or more open in some part. Hence it comes, that sometimes we may find a pulse in the tee



sometimes in the gums, and sometimes we cannot. From hence I did certainly observe, that Boys whose pulses are alwayes swift and frequent were in an undoubted fever, by this one token; as likewise in tender and delicate people by griping their fingers, I could easily perceive the pulse of their fingers when the Fever was in its strength.

On the other side, when the *heart* beats faintly, not onely not in the fingers, but neither in the wrist, nor in the temples can any pulse be felt, as in fainting, hystericall symptoms, defect of pulse, weak people, and those that are departing:

Here Chirurgions are to be admonish'd, that they be deceiv'd; because in the cutting off of members, the cutting away of the tumors, and in-wounds, the blood does indeed come forcibly out of the *arteries*, but not alwayes with leaping, and that small *arteries* doe not beat, especially when they be tyed with a *ligature*. Beside, that the *vena arteriosa* hath not only the constitution and *tunicle* of an *arterie*, but that it does not differ so much in the thickness of the *tunicle* from the *veins* as the *aorta*. The reason is, because the *aorta* receives a greater impulsion of the blood from the *left ventricle*, than that does from the *right*; therefore it has the constitution of the *tunics* so much the softer than the

the *aorta*, by how much the *right ventricle* of the *heart* is weaker than the left: And by how much the contexture and softness of the *lungs* does abate from the habit of the body and flesh, so much does the *tunnacles* of the *vena arteriosa* differ from that of the *aorta*.

All these things doe constantly keepe proportion in men, for the more brawny and musculous, and of harder habit of body they are, and the stronger, thicker, and more fibrous heart they have, so much the more answerable *ears* and *arteries* proportionably they have in thicknesse and strength. Hence in those creatures, the *ventricles* of whose *hearts* are smooth within, without roughnesse, *portals*, are with a thinner wall, as in *Fishes*, *Birds*, *Serpents*, and very many sorts of creatures in them the *arteries* differ very little or nothing from the thicknesse of the *veins*.

Besides, the *lungs* have such large vessels, their *vein* and *arterie*, that the trunk of the *arteria venosa* does exceed both the *cervical* and *jugular* branches, and are so full of blood, as by experience and my own eyesight (nor was I deceived in the inspection of those things which I saw in dissected creatures) that upon the wounding them, all the whole blood has run out; the cause, by reason that in the *lungs* and in the *heart* is the fountain, cellar, and treasure



blood, and store-house of its perfecti-

Likewise we see in Anatomical dissection, that the *left ventricle* and the *arteria pulmonalis* does abound with so great a quantity of blood, and indeed of the same colour and consistence with that with which the *right ventricle* and the *vena arteriosa* is fill'd, alike black and clotted, because the blood passes hither from thence continually through the *lungs*.

Lastly, the *vein* call'd *arteriosa*, common to the constitution of an *arterie*, the *arteria venosa* of a *vein*, because in truth, both in function, constitution, and all things, that is an *arterie*, and this a *vein*, other than is commonly beleev'd; besides, the *vena arteriosa* hath such a wide *orifice*, because it carries a great deal more blood than is necessary, for nourishing of the *parts*.

All these *Phaenomenas* to be observ'd in dissection, and very many more, if they be duly weigh'd, seem to clear the foresaid matter abundantly, and indeed to confirm it, without all to goe against the common opinion: Seeing it is very hard for any to demonstrate by any other way than we have done, for what cause all these things are appointed.

FINIS.





THE

DISCOVERES

OF

OF AMES DE BACK,  
Physician in Ordinarie to the  
Town of Rotterdam.

In which he handles,  
*The nullitie of spirits,*  
*Sanguification,*  
*The heat of living things.*

There is premis'd,

A Speech to the Reader;

And annex'd,

In Addition, in defence of  
*Harvey's Circulation.*



---

London, Printed by Francis Leach, 1653.

THE FIRST PART OF THE HISTORY OF THE REIGN OF HENRY THE SEVENTH

BY JOHN HALL

IN TWO VOLUMES

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A  
S P E E C H  
TO THE  
R E A D E R S.

*in which are handled the honours and reverence  
done to the Inventers of Arts, the liberty of  
opinion more esteem'd, Truth is the foundati-  
on of the Art of Physick, Harvey is the Au-  
thor of the Circulation of the Blood, by which  
many Positions of the Antients are overturn'd;  
the reason of the Author's writing a brief rule  
of the compend of Physick.*



Ow much those were esteem'd,  
who amongst the Antients ear-  
nestly endeavouring for the cō-  
mon good, & watchfully caring  
for the safe ty of their Countri-  
men, did communicate their in-  
ventions & labours to their coævals & posteri-  
; Rewards of old propounded, and Honours  
infern'd upon them do sufficiently shew. The

*To the Readers.*

Inventors of Physick were number'd amongst the Gods; those that did excell in their Studies, and in the Liberal Arts, being number'd amongst the Muses, and the inhabitants of *Parnassus*, were all adorn'd with divine honours. This was always the care of Cities, Commonwealths, and founders of Kingdoms, to incite the wits of their Subjects by such rewards, and with a delight and prick to the best Arts and Sciences; Nor were they content with this, but in diverse places by their great pains houses have been built, by which they might allure strangers who were excellent in learning, who were to be entertain'd upon the charge of the Publique, with the addition likewise of rich rewards. There are likewise Colleges erected for the teaching of youth, which being imbued by the learning of Masters, and tending to the like honours, were invited to add their own Inventions to those of the Antients by new rewards. Neither by the careful diligence and endeavour of posterity, was there any thing thought to be derogate from the deserts of the Inventors of Arts, as if they had not taught the Art intricate and absolute in all points: Better was that the ground-work was laid by them upon which, as upon a path or way, the Son



*To the Readers.*

If Art might walk, that they might fitly be taught in Sciences, or being inflam'd with the love or desire of knowledge, they might be advanc'd to higher things. The old Man begins his positionall doctrine, *Art is long, life is short*, well considering the businesse, the length of our Art hath not only vanquished one mans life-time, but all ages; which having as yet not received perfection, will in the time of our posterity, perchance, never find it. So ready are occasions for search, and so great the difficulty of judging, especially if being bound by the certain rules of the mind, they be hinderd to run out further for the search of the truth. The never-enough esteem'd Interpreter of *Hippocrates* in his 3. B. *Nat. Facult. Cap. 10.* *Whosoever*, sayes he, (not speaking any thing of the perfection of Art) *desires to know any thing more than ordinary, ought to excell others, not only in the rudiments of learning, but also be possesst with a mad love of truth, endeavouring day & night, to learn those things which are taught by the most famous men, judge, spend much time in searching, and consider what sayings agree with those things which are obvious to the sense, and which doe disagree.* Besides the same *Galen* does so much esteem the freedom of searching out of the truth, that in

*To the Readers.*

6. *Epidem. Aphor.* 7. He call'd it a tyrann<sup>y</sup> that any bodie should be restrained to any one opinion without handsom demonstrations. Likewise 6. *Epid. Sect. 2. Aphor.* 17. hee does sharply reprove those that bequeath and give themselves over to their masters without examination. *Whosoever*, says he, *does confesse themselves to be the servants or waiters of any person, those so soon as they find any thing written by him, presently approve of it both rashly and unadvisedly*. From hence it is manifest, how candidly those clear lights of Physick did love the light of truth, to the adorning of Physical art and common safety of all; so that they prefer the freedom of enquiring after truth, sifting of reasons, and giving opinion concerning any thing, (though themselves were the guides) to tyrannie and servitude, for the prisons of these being broken, free spirit is master of it self;

*The lively force o'th' Soul o'recame, and past  
Beyond the walls o'th' flaming world at last,  
And o're this vast in soul and thought doth drive:  
Whence victor, he relates what may arise,  
What not, how, and by what means t' all things pow'r  
A bound is set, they cannot passe their hour.*

Being instructed, and as it were bred from my youth in the doctrine that these Heroes left behind them, I did earnestly embrace the

pre



recepts given by them, and that had as it  
 were a strong tye upon me to defend them,  
 and for good reason, seeing the fathers of  
 that art did create us sons of the same, and  
 we owe it to them that we have profited in  
 the art, and we are forced to confesse, that  
 we have gaind the knowledge to which we  
 are risen, by their assistance, and the help of  
 these things which we receiv'd from them.  
 Besides, the sonnes of art are tyed by an Hip-  
 pocraticall oath to esteem one another as  
 brothers, and to esteem of those of whom  
 they learn'd the art, as of their Parents; if  
 then a son owes honour and reverence to his  
 father, why should not we, who are the  
 sons of art, reverence and respect our patrons  
 and parents?

Upon their advice, I did set down and re-  
 solve in my mind, having taken the degree of  
 Doctor, to essay nothing in the practick, un-  
 lesse being induced to it by a tryall of reason,  
 if I heard any thing well done or spoken  
 by another, that I should endeavour to  
 search the reasons of the thing as it came to  
 mind, that I might at least satisfie my self; I  
 being thus prepared in mind, it so happened  
 about 15 years agoe that the Anatomical  
 Exercise of *William Harvey*, concerning the

To the Readers

motion of the *heart* and blood, did fall into my hands, after it had been out about five or six years, having drawn a great many learned men to his opinion in this treatise, he leaving very many Positions of the antiem doctrine on which I had grounded my self, he was pleas'd to say, that the blood did not move through the *veins* from the *liver* for the nutrition of every part by their attraction, but that the same was driven from the *heart* through the *arteries* for the aforesaid use, and that the superfluous part did return through the *veins*, that being again refresh'd in the *heart*, and imbued with new spirits, it might be again carryed back to all the members, and that it might be returned again often through the same way by continual circular motion. This new thing I did examine, which at the first entrance did seem very easy to be refuted, but being weighed in a just ballance, and having added reason my own ey-sight, it was found inepugnable, (nay, the very prick of truth enforcing to be embrac'd) with both arms; what should I doe? must *Hippocrates* be left, *Galens* slighted? no, if we follow the truth fenced with reason and our sense, we are still *Hippocrates* his, we are still *Galens*. *N*

this



*To the Readers.*

being to be contemned, says the old man, *not*  
going to be judged rashly. Hence he com-  
mands us to examine the writings of the most  
famous men, when they are obvious to our  
senses, or disagree from them. Rational and  
dogmatical Physick consists in true grounds,  
not is any thing to be thought firm and esta-  
blish'd, but what is approved by truth. This  
Heresie, first thought to be so in Physick,  
grew dayly, so that it walks not only through  
the Universities of *England*, his native  
Country, but likewise through those of *Ger-*  
*many, France, Italy*, and our Universities  
of the *Low-Countries*, and besides a great  
company of learned men, it tied also the Pro-  
fessors to it in many places, of whom, some  
in their publick Lectures and Disputations,  
as also by books written to that purpose, did  
at last divulge this opinion, with the great  
applause of Students, that you shall scarce  
find a Doctor created, who knows not, yea  
does not approve of the Circulation of the  
blood. But as from one true Position a thou-  
sand consequences are taken agreeable with  
reason, and a thousand leaning upon one  
which is confuted do totter and fall; so did  
it come to passe, that by setting down the Cir-  
culatory motion of the blood, innumerable  
axiomes

axiomes of antient writers were overturn'd whence it comes, that all the order of teaching is troubled, and the doctrine of Physick is endeavourd and learned altogether preposterously and confusedly, without any certain method, which ought to be established by Positions link'd together, and marshall'd in due order.

This is the reason that all doe somewhat disagree in one thing or other, either in the Cause of the motion of the blood, or in the Manner, or in the Effect, or leave it as a thing too laborious or hatefull to their colleagues, not searching farther in it, after they had receiv'd, and by their books published, approv'd of the invention of *Harvey* concerning the Circulation of the blood, being thereto perswaded and convinced by reason, and their own ey-sight. But it being not handsome for me to neglect the scrutiny of this businesse, or to stand in a doubtfull condition, I did undertake to search into, and examine the reason, the action, and use of the parts, and did endeavour through carefull search to peece up and illustrate in a little method that order which had been destroyed. But this was not done with so great silence, but that there did often



*To the Readers.*

se discourses of it amongst my colleagues and  
other my familiars, as likewise, sometimes  
those things which did chance to concern the  
Circulation of the blood were in our Anato-  
mical demonstrations handled and canvas'd;  
hence it happened, whilst some did search  
after these things, and that seriously, new  
doubts alwayes occurring, they did earnestly  
and friendly intreat me, that I would publish  
for common use such things as in this matter I  
had studied: which although it was trouble-  
some to me now growing old, it being two  
and thirty years past, since I gave my self to  
practice, and (as it is usuall) I had in a man-  
ner left all the Theorick part, (if this matter  
concerning Circulation had not waken'd it)  
there could be not time enough for me (being  
both busied with my own affairs, and with my  
practice) to bestow upon this work. Yet that  
might please my friends, I suffer'd my self,  
reluctant and unwilling, at last to be intreated,  
somuch, that I might adde something to the  
treatise of Doctor *Harvey* of the *heart* and  
*Wood*, which might be to the same purpose;  
which Book *Arnoldus Leers* a vigilant Stati-  
oner hath lately given to the Presse: I did  
therefore undertake to write a Discourse con-  
cerning the *heart*, partly because it agrees  
with

*To the Readers.*

With Doctor *Harveys* purpose, and partly because I thought that the scrutinie of the *hypothesis* was more accurately to be handled, and with a more diligent care to be enquir'd after. If the beleev'd excellencie and splendour of it hath so bewitched the minds of both Antient and Neoterick Philosophers, and so blinded their eyes, that not seeing the clear light of truth, they receive nothing but things obscure and conceiv'd in their own imaginations of truth. Therefore, whilst I endeavour to take away those mists & cataracts frō their eyes, I earnestly intreat that I be not blam'd for such one as endeavours to take away from the Antients their proper honour, and from the Fathers of the Art the reverence which is due to them, and as if I would diminish brotherly concord amongst the Sons of Art, if I expose that little which I have conceiv'd in my mind being call'd to counsell, whilst the reformation of the Method of Physick is in hand; and I be accused as if I would further disorder it, ( it being not enough for me that by bringing in of the Circulatorie motion, the natural and vital faculties are confus'd ) and reject *Hippocrates* his antient *Oeconomie* of the body, hitherto received of all, and overturn the foundation of that doctrine; I hope it will



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remedie for that evill, if I excuse and free my  
self of it in the very entrance. Since the Ana-  
tick Method of teaching did alwayes seem  
most commodious to the most eminent in  
physick for the explication and search of hu-  
mane nature, they took a division out of *Hip-  
ocrates* writings, by which they doe divide  
the bodie, into things containing, things con-  
tained, and things impelling or impulsive:  
things containing, they call the solid parts;  
things contain'd, they call humours; things im-  
pelling, they call spirits. But because the  
utilitie of substance which is ascrib'd to spi-  
rits, may infer indeed a mobility or prompt-  
ness to motion, but not an active motion; be-  
sides that, if there be any such, they must pass  
amongst things contain'd, and being also de-  
stitute of life, they must needs be impell'd by  
some other thing; if they will have their divi-  
sion firm and established, some other thing  
must be thought on, to which this force and  
power of impulsion may be more competent  
and agreeable. This will come to passe, if  
you divide a living Man into that which con-  
tains, that which is contained, and that which  
is impulsive, understanding by that which is  
contain'd, the solid masse of the bodie, as it is  
the Anatomists handled as a subject; by  
that

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that which is contain'd, the blood, or nutritive humour, as it is contain'd by the solid substance of the bodie. Nor did we infer that there are more humours in a Mans bodie when all of them do make a part in the constitution of the blood; for either they do concur as parts constitutive, or in the excretion of it are separated from it as unprofitable excrements. By the name of the impulsive, not the spirits, but the incorporeall force is to be called, which is all in all, and all in every part, not containable by it, and all for and impulsion, this enlivening and impelling, the order'd parts doe perform and execute their actions.

I call the generall doctrine of man *Anthropologie*, the parts of which, I do ordain to be, according to this division, *Psychologie*, *Somatologie*, and *Hematologie*, into the doctrine of the soul, bodie, and blood, in man all functions which are seen, as well hidden as open, are perform'd by the soul, impulsor, by the body dispos'd operating, the blood helping and concurring as a medium.

*Psychologie* is a doctrine which searches out mans Soul, and the effects of it; this is the part of man which is the implanted cause



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All motions and functions, without which a man cannot consist.

Hence perchance an *animal* is call'd *anima-*, whatsoever hath the beginning of motion in it. According to the diversity of actions, and effects appearing in the body, we set down divers powers and faculties of the soul.

A faculty is a force and aptnesse of the soul to act and perform its functions, shewing itself in the actions of the body.

We see that the soul does chiefly endeavour three things in the body, to wit, life, a better and more commodious life, and at last eternall life: according to these three actions we ascribe unto it three faculties, under which afterwards we do comprehend the rest as subservient.

Whilst the soul does procure life to the body, we call, that the vital natural, or likewise the Vegetative faculty.

This faculty we divide into preparative, dispensative, and assimilative, which for the greater part shall be canvass'd in this our course.

It bestows a better life upon the body when it adorns it with motion, sense, and most of all with the benefit of reason; that we call the

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the Animal power, by which it distinguishes Animals from Vegetables, but from these we call a man Rational.

The soul, since it cannot preserve life the Individuall, by reason of the unfitness of the substance of which it is compos'd it does endeavour to perform that in another which faculty we call Procreative.

Those parts are appropriated to the powers of the soul, by which they are shown which (as the humours likewise) are wrought and acquire their perfection from it.

Wherefore, since after the enumeration of the faculties, the number of the functions and actions of the parts is likewise clear, and upon them their works and effects do ensue if I do bind up the order of *Psychology* in few words, I hope I have perform'd the same as all the rest.

I do think that this *Anthropologicke Science*, because it is meerly Physical, is to be called Physiological, but that which does comprehend the doctrine of Diseases, whether they be natural or pretended, is to be called *Pathology*. By the one the actions of the body are very well perform'd, by the other they are hurt;



*To the Readers?*

This range sicknesse and its causes & accidents  
are handled; in that, health and its causes  
and accidents likewise, but the Physician  
performeth his cure by preserving the health,  
and restoring it ( if it so please God ) when  
it is lost.

This narration, of a compendious method  
we have set before our book, that it may be  
known; that those things which in it we  
subject to the tryal, do not come out without  
due order; in which we also did endeavour to  
be so brief, that those things which are set  
down and clearly enough explained by o-  
thers in the descriptions of things obvious;  
we did passe by, thinking it unnecessary to  
repeat them, and doe only mention those  
things, which being back'd by reason are  
different frō the vulgar opinion. These things  
might have come abroad in a Philological  
style, and adorn'd with a more eloquent  
style;

*But we so learned must not be,  
Our Muse hath more austeritie.*

Nor is it decent that this purpose so far dif-  
ferent from the vulgar opinion, should be spo-  
ken like a Fable that were to be related, as  
those doe that take great delight to extoll ab-  
surd things, a Gnat, a Lowse, or an Ake, with  
I rare

*To the Readers.*

rare eloquence, and highest praises; or things absurd and false by the judgement of all the senses, as that women are not *homines*; or do endeavour not only to defend things far more absurd, but by dawb'd and sophistical arguments endeavour to cloath them with a likelihood of truth, that by these things they may show the quaintnesse of their wit, and the excellency of their learning. I had never such an intention, nor being mov'd by any other reason than the intreaties of my friends, neither from any arrogance or desire of contradiction, but meerly thereto induced by the love of truth, do I bring these things to the touchstone of truth, which is alwayes uniform and alike: it self, the most generall rule of all, being neither darkned with any sophistical argument, nor with unknown and feigned words: which if they be not fenc'd with true reasons, and ocular testimonies, reject them, but if you think them worthy your consideration, and be received, enjoy them, and farewell.



To the Reverend and most  
Learned Man, William Harvey,  
Kings Physician.

**C**Onsidering with my self under  
the safeguard of whose name  
this our Discourse of the Heart;  
being to see light, might most  
creditably and handsomely come abroad, I  
thought it could be dedicate better, and with  
more reason, yea more adorn'd by none, most  
learned Harvey, than by being consecrated to  
your immortal name. It was fit it should be of-  
fer'd to none besides you, you only have power o-  
ver it, to you alone it owes the beginning of its  
life, without you it had not seen the light, nor  
could it ever come abroad to publick view; I  
confesse ingeniously, had I not been rowz'd and  
ur'd by your invention, no occasion ever had  
offer'd me, neither to pass the antient bounds  
of Learning, nor to make further search into  
the parts of Nature. Therefore willingly and de-  
servedly

servedly do I dedicate & offer it to you, in which  
 (me thinks) I perform two things, for I shew  
 the gratefulness of my mind, and a most learned  
 man does reap a part of the fruit of that Learning  
 which was acquir'd by the acuteness of his  
 own incomparable Wit. There does but a little  
 by this our Offering accrew to your Name  
 which is already extoll'd to the Heavens, being  
 known over all Europe, even to the Indies  
 and the most remote parts of the World. I  
 know we are indebted further, but because  
 great matters goodwill is enough, let it suffice  
 that a gratefull mind is presented to you with  
 this Discourse, seeing we are able to do no more.  
 We adjoin, to this Present, a Petition, earnestly  
 intreating you, that you would vouchsafe  
 make us partakers of those innumerable Observations  
 concerning the Fabrick of Mans Body  
 which you have by you found out by your own  
 diligence, as from the disquisition you put forth  
 known, to publish them for common use,  
 further oblige to your self all lovers of Truth  
 especially him who is yours,

J. De Back.



CHAP. I.

Of the First Section, of  
James De Back his Discourse  
of the Heart.

*He that is to give his opinion in any businesse  
what manner of man he ought to be; the  
heart as yet not throughly search'd; how  
much the Antients did esteem it; the ex-  
position of its Etymologie; there is no rule  
of one part over another; the Heart is a  
servile part; Faculties are not influx-  
ive.*

*He that is to give his opini-  
on concerning the truth  
of any businesse, ought  
not to be mov'd by the  
authority of any famous  
man, nor with the love  
of an opinion receiv'd  
before, nor with the desire of any  
thing, but only trust those things which  
seen with his eys, known by his touch,  
are confirm'd by reasons drawn from  
clear testimonie: that which is the inven-  
tion of the Imagination only, and ground-  
ded*

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ded upon no Sense, although it be commonly received by all, yet he is not bound to adhere to it, but that he would rather embrace those things which are evident, and approv'd by perceptible and sensible reasons.

But let him especially resolve upon this, whosoever undertakes to examine the motion, frame, and use of the *heart* by true and certain reasons.

*Momus* reprehending the works of *Isaac*, amongst the rest, requir'd that there might be a window made in the *breast* of man, through which his *heart*, and that which lay hid in it, might be seen: But notwithstanding the whole *breast* being open'd, and the *heart* it self being seen again and again, both live and dead, as likewise being assisted by the diligence, and accurate observations of most learned men, yet there has beene a difference before our age, even to this time, nor as yet can grave and famous men in their learning agree, concerning the cause, and effect of its motion. There are some who never forsaking their commonly received opinion had rather erre with great many, than think well with a few; others leaving ocular testimony chuse rather to follow such things, which were never seen nor never found out by any of the senses; upon which notwithstanding



upon foundations they build a great many things, which being vented as undoubted truths by men indeed skillfull and learned, they do embrace with might & main, and go every one of them stiffly with great fervency, and alleging of reasons, to defend their own positions; so that you may justly doubt to which part to adhere.

Dr. Will: Harvey the King of *Englands* most expert Physician, and most excellent professor of *Anatomic* in the College of *London*, has shew'd the means lately by his finding out the motion of the *heart* and *Blood*, to get out of this labyrinth, as it were with *Ariadnes* thred, if it had not been that the Author being too curious in the observation of the *tenets* of the Antients had too religiously worship'd that Principle which they attribute to the *heart*.

Besides, this age fertile in the production of most acute wits, who do excell both in our art, and in Philosophie, has furnish'd us with a man of an incomparable ingeny, being indeed a stranger, but remaining here in the Low Countries, who in his most learned writings, rejecting many of the *tenets* of the antient Philosophers, and giving us other rules more clear than the noon day, has fram'd us a new opinion concerning the cause of the motion of the *heart*, departing a little from the purpose of the venerable Doctor

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*William Harvey*, and though he do agree with him in the invention of the circula motion of the blood, yet does he not agree with him in the cause of the motion of the *heart*; whether or no he have reason so to do, amongst other things which have been heretofore spoken concerning the *heart*, I shall begin to examine.

Since many ages the *heart* has had this report, not only to be the principle, or only beginning of life, but of the whole body, in which the Soul has taken up its dwelling house, and from which as from a fountain all the vital faculties and spirits come to flow. *Plato* calls this the seat of the Irrascible Soul: *Aristotle* calls it the seat of the Vegetative, Sensible, and Ratiocinative Soul. Besides it vaunts it self to be the store-house of our moisture, the furnace and nutriture of our native heat, the Sun of our body, by whose influx all the bowels are warm and refreshed: Moreover here they say that artificial fire of *Zeno* is contain'd, here the Divine and celestial heat is preserv'd, which the Poets feign *Prometheus* to have stole from heaven, that he might put life in man; Therefore it is called the first moving, and the first mover, and the first if not the only store-house for making of blood.

And for so many gifts and so many dignities, it is called the most noble part



the body, which having the chiefest seat,  
proclaimed as Monarch, it only adm-  
istring the Government of the Empire.

*Its nought when many reign lets have one  
King.*

Hence they derive *Cor* from the Greek  
word *Κῆρ*, being contracted from *Κέαρ*,  
which comes from *Κέω* to burn, and the  
Greek word *Καρδίαν*, they will have to  
ound as much as *Κράτειν*, from principa-  
ty, or government, when it is rather  
deriv'd from the verb *Καρδαίνω*, which is  
to move or shake: It is very well called  
hart in our language, which in the latine  
signifies hard, because it is the hardest a-  
mongst the soft and fleshie parts, or (for  
harden is as much as to endure) because  
it continues in its action and motion with-  
out any fatigation.

With these titles of honour, and more,  
not divine and supernatural (for, it is  
nought, by the heat of the *heart*, without  
the help of the Soul, that all the actions  
in the body, Thinking only excepted, are  
performed) like *Æsops* crow, the *heart* is  
adorned as it were, cloath'd and decked  
with the feathers of other birds, with so  
much confidence and zeal, that it were  
impiety to speak any thing to the contra-  
ry: But let us see whether or no (as she,  
when the rest of the birds did with good  
reason require back their own feathers,  
did

did dance naked) it will have any thing else besides leaping left, when the Soul and other parts have received their own.

*Æsop of Phrygia* does explode the domination of one part over another, in his Fable concerning the contention of the members about Principality.

But seriously how shall it command which it self serving for an instrument for the actions of the Soul is made to serve the whole body at all times without intermission, and goes on just like an aff drawing a mill, either slower or quicker according as it is prick'd forward?

But you will say we cannot want the help of the *heart* in our life, and that life begins with the motion of the *heart*. This same comes to passe in playing upon an Organ, where the Servant first blows into the pipes with a pair of bellows, nor without that blowing can they play, yet it is not said to play, but he that tunes the notes right.

The greater dignitie or primacie and perfection does not therefore suit with any part, if the Soul do want its assistance first, or that it be made before other parts. The Navell-gut and the Secundum shew this, being form'd before other members, and the *heart* it self, for they are parts of the birth too, but the birth being perfected, and brought forth into the

work



world, they are thrown away as unworthy and unprofitable.

Things do not become perfect at the first, but become such by delay and longer time.

It is an imaginary thing, if not different from reason, to assert, that Faculties do flow from any part; for they are the powers of the Soul, which is present everywhere: it is judged to be in the whole body, and every part of it, with all its faculties, and its granted that like an Artisan it does perform all the actions of the body, if it find fit instruments.

The Members being Organs of the same Soul, cannot refer their aptitude to do any thing more to the *heart*, than the rest of the parts, with who they have life in common. I believe no man thinks that the temper of similaries, and the conformation of dissimilaries consisting in fit form, place, number, and magnitude, and the agreeable union of both, flows from the *heart*, or out of any one part into another.

These and other things are slight, nor much to be esteem'd as unprofitable cavils: but if being Author of the perfection of blood, the elaborating of spirits, and the more peculiarly implanted heat, and of these two first actions, as likewise of all the rest (as they think) be prov'd unfit to be attributed to the *heart*, all those great  
pre-

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prerogatives pinn'd upon it will easily  
o'rturn'd and fall.

C H A P. II:

*The acception of the Etymologie of spirit; the  
antients Definition of it; no such thing  
found in the body; as there is a threefold  
substance in every part, so likewise  
the blood; spirit and heat are ill confus'd  
spirituous substance inseparable from the  
blood; spirit is not the tye of the Soul and  
body, nor the nearest instrument of the  
Soul; The animal facultie is not drawn in  
to action by the spirits; how sensations are  
made.*

**T**HE Etymologie of *spirit* is diversly tra-  
ken, but that which is here to be con-  
sidered, is Defin'd by some to be, A very thin  
and subtle body, hot and most pure, begot-  
ten of the thinnest and most sincere part  
of the blood; or according to others, It is  
a substance very thin and small, made up  
of air and the vapour of our blood, being the  
first and nearest instrument of the Soul  
undergoing its functions.

From which Definitions is gathered  
that the *spirit* is a certain substance di-  
vers from the blood, subsisting apart, and



by it self; because it is made up of its finest and thinnest part, or because it is said, that it is made up of its vapour and air.

But I beseech you where was there ever any such thing found in the body? it would be found in the habit of the body, or contain'd in the vessels which are ascrib'd to it, the *arteries*, *veins*, or *nerves*; which to affirm is imaginary, nor is it confirm'd by any demonstrations.

In the habit, or indeed in any part of the body, there is a threefold substance considered, that which is spirituous, humorish, or solid; but to separate these were to dissolve the frame of the part, no less than if one should dissolve any thing consisting of the four Elements, into substances existent to the sense; this tye of substance being dissolv'd, it does not on-leave to be a part of the living creature, but likewise a part of the body.

If it be found in the *vessels*, it will be there where it is thought that there is the greatest abundance of it, that is to say in the heart and the *arteries*: but the authority of *Galen*, and experiment drawn from case it self, which is most of all to be trusted, teaches the contrarie, that nothing but blood is contain'd in the *arteries*.

If you tie the *arterie* above and below, and open it bewixt the two *ligatures*, you shall

shall find nothing but blood, and so much of that flowing from thence, as the capaciousness of the *arterie* was able to comprehend: If any say that it flows with red blood, and that it is the thinnest part: that blood which is contained in the *arteries* and *veins*, that we easily grant: but in the mean time we conclude, that it is not any thing separable from the blood, if how can it be separated from the blood that together with the blood is driven with so swift a motion?

It is to be believ'd that it is the aerial part of the blood, of which when it is destitute it is called dead blood, atter, or goar, altogether unfit to perform the functions of blood, for it is part of its substance. The blood likewise in the blood is threefold, as water in all other parts (to wit the grosse part, or thickning, the humor, and spirit) but not separable without the destruction of the form of blood.

They that discourse of *spirit*, do so commonly found it with *heat*, that they deny that one can be without the other; as likewise they aver that they are really and substantially the same, and do only rationally differ, and that it ought to be posited that there are as many *heats* as there are *spirits*; even as a certain *heat* fix'd to every one of the parts is connate at our first beginning, by the aid of which all nature



ctions are perform'd, so likewise that there is a *spirit* infixd and implanted at our first birth, which does administrate all functions; for that cause they do conclude that how many parts soever there are different in their substance and temperature, there are so many fix'd *spirits* distinguishable in their *species*.

But because this *heat* and *spirit* of every part does vanish very readily, and constantly, there ought say they from the principal parts another be sent, call'd the *incent*, by the continual access of which, the loss of the former may be repaired.

Which being granted (though we do not grant that *heat* does so well agree with spirituous substance) I ask you, for as we are nursed by a-like, & refresh'd by it, may the blood which flows in the vessels all not be said to be of a threefold substance, and that unseparable, seeing it does nourish and refresh the parts that are made up of it?

Nor do I think that it can be certain, that the spirituous substance can be refresh'd in nutrition, without both the other two, unlesse they likewise receive their part according to just proportion.

And likewise ask; seeing the *spirit* or spirituous substance belongs to the constitution of the parts, as likewise of the blood, why it should be consider'd apart? for to multiply

entities without cause, is beyond the abilities of all Philosophers, and is repugnant to reason.

But let us see for what good end, or what use they think that *spirits* were given to living creatures; that there may be, they, a connexion of the Body with the Soul, because the incorporeal and immortal Soul of man could not be conjoyning with a frail body but by the intermeditation of *spirit*.

Forsooth indeed as if an incorporeal substance could not agree with a solid body but by the intervening of something more subtle; when notwithstanding it has no greater agreement with one than with the other, that assertion seems altogether vain.

They say moreover that it is the instrument of the Soul, by which it performs its actions: but whether is this taken of that which is influent or implanted? That which is implanted is of the substance of the part, or its spirituous substance, which being combined with other performs no actions apart. The Soul given to the parts to perform actions is an impulsive, not as an implanted spirit. But an influent spirit whilst it is not living but a substance inseparable from the body unless it passe into the substance of the part, cannot immediately help any thing.



in the performance of any action. For the part being prepar'd with a just temper, a fit frame, a right union, being enlivened by the power of the Soul, and being warm'd and made movable by the regular motion of the blood, does in my opinion perform any actions.

There may be a great difficulty rais'd as concerning the *animal faculties*, which are perform'd both by sense and motion, through mediation of the *nerves*, those being stop'd, held or cut, the part it self remaining whole, yet notwithstanding sense and motion is taken away, as they affirm, because the passage of the spirits is stop'd.

For they being most thin substances, and quickly passing and repassing through the pores of the *nerves*, to carry and bring back the facultie to the member, and the sensible *species* to the brain; The businesse being well look'd into and rightly consider'd, that going and returning of the spirits, even of the lightest air, though free, cannot be so sudden, even in imagination.

Why do we multiply Entities and fly to those things which are not demonstrable? must follow things evident, which may be perceiv'd by the sense.

It is better in my opinion not to expect that from the interception of the spirits, but rather from the hindering of that  
X
action

action, which is both common to the *nerves* and brain, by the mediation of a certain humour with which they are imbrued from the brain.

For it is to be thought here are likewise as in other places, a spirituous substance, of which the *nerves* and the nutritive juices with which they abound as well as other parts, and the blood it self are compounded, and which being altogether inseparable from the fleshie and solid parts, cannot subsist a part.

But lest any should doubt of the existence of this humour; if a *nerve* be but once touch'd with a very prick, so great abundance of it sometimes flowes out, that it can be hardly stop'd by an unskillfull Chirurgion. For it is to be observ'd, that as the body is continually and incessantly refresh'd with new nutriment, so the *nerves* are refresh'd continually without interruption, not with blood immediately passing out of the *arteries*, which perchance belongs to the flesh alone, but with a juice which they have in common with the brain, from which they receive it in great abundance, as well that it may be nutritive to them, as that it may be communicated to other parts endued with sense.

They doe evidently demonstrate that the *nerves* have their nutriment prepared by the brain; first of all, because they



joyn'd to the brain, as likewise the spinal marrow, and inseparable from it without hurt, and as a portion drawn over the meninges of the brain, insomuch that you should say that the brain were extended over all the body.

Besides they have neither *arteries* nor *veins* which are any ways visible.

Nor is there any difficulty to be made of the abundant increase of this humor, which is continually by pulse driven into the *veins*, nor of the impulsive force which moves it into the remotest parts, as if the brain were not endued with so great power, yea since in so great abundance the blood is carried by the *vena carotides* into the brain, much more than it stands in need of, if it were not for common use, that with this continuall pulsatory motion it heats without rest, even like the *arteries* themselves, and does likewise deposite in the *nerves*, the juice (the superfluities which the *veins* doe receive) being separated by its own segregatorie power, and mov'd forward by its own weight, and mov'd forward by the motion of following pulses. These being once set down, it is easily perceived how the senses are mov'd, or sensations are made.

The brain being in continual motion, having the *nerves* joyn'd to it, and pers'd through all the sensible parts,

whilst it does through them move the nutritive juice, it does apprehend the least touch even in the most remote part, which is stirr'd up by the sensible object.

Scarce is either any part touch'd, nor the net of the eye affected with any visible object, but from thence the motion of the brain is alter'd; as in the stretching of a string if it be held whilst it is in play, we hear the sound of it alter.

This action being so sudden, yea much swifter than the going and returning of the spirits can be, and so evident and perceptible, who will not more plausibly think, and that it ought to be resolved with greater reason (since this continual action is common to all the *nerves*, being scattered through the sensible parts, together with the brain, which is environed with the *meninges*, by the mediation of this nutritive humor) when through obstruction, compression, and incision of a *nerve* the action of a part is hurt, that it proceeds from the action of the brain which is hurt, which was common with the *nerves*, rather than to fly to the mission & removal of spirits, which appear no where; for the immission of nutriment being stop'd, the brain can neither perceive beyond the *texture*, nor advance its benevolence thither.

Therefore I conclude, that since there is neither any such substance in the whole



dy to be found, which will agree with the definition of spirits, or which is agreeable with any end which is attributed to spirits, that there are neither any spirits, nor can they be elaborated in the heart; for which thing more reasons will offer themselves whē we shall be employed in refutation of the *Hematosis* of the heart, to which before we come, it seems worthy our pain to relate in what manner I think it is perform'd.

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SECT. II. CHAP. I.

*The definition of the blood; What sanguification is; how it is begun in a birch; the aptnesse to nourish, not colour, is that which makes blood; Sanguification is not performed in one part alone; Concoctions come to be by addition and detraction.*

**B**lood is an humour familiar to the nature of Animals contain'd in the *veins* and *arteries*, containing in it matter fit for the nutrition of the parts administring heat to the whole body, together with nourishment for the sustentation of life.

The Elaboration of this humour is call'd *Hematosis*, or Sanguification. This is perfected two manner of ways; according

to the first manner the *Hematosis* is perfected in the parts themselves or in the habit of the whole body, when the blood again and again passing about the body in a circular motion, and affording recruits to many places, and at last receiving a similitude of the parts (for it cannot receive a similitude from any better than from those to which it is to be assimilated) it is prepared that it may be fitted into its substance.

The other is the preparing of the nutriment or meat and drink newly received that being mix'd with the other, it may pass without hurt to the innermost parts of the body, that it may be fitted to nourish and perform the rest of the functions of the blood.

This is not perfected without the intervening of the blood prepared according to the former manner, for that which newly come in becomes not such, with requisite addition in divers places much dilution, and afterward it is joined with a perfect mixture: It is certain that by the first life is begun, by the second it is sustained and receives its increase.

In the first beginning of a creature where all things are unperfect, and so small they are known to God alone, by reason of their smallness they appear not to sense, I do imagine that so much moist



ry blood is cold, do digest their food being swallowed down whole, and are aravenous without measure.

If any one desires to see the truth of this opinion with his very eys, let him look into the stomach of a fish, of ordinary bignesse, when he has swallowed another for food, whose body, because it is not all at one time consumed in the digestion, but the exterior parts, and those that are nearest to the bottome of the stomach, after a little while he shall see the reliques of the swallowed fish, and about them the part digested, and near to the wals of the stomach a certain juice (waterish indeed, but not so much mix'd with the food) newly come out of the pores of the inmost *tunicle*, like swear, that being more diluted than that which appears almost digested, it might be thrust into the *bowel* through the *Pylorum* by the force of the contraction of the stomach.

Indeed it behooves that that which is strange should be diluted with much and familiar moysture, deprompted from the body it self, and which is continually and incessantly recruited by the new nutriment, lest passing into the inwards in a dissimilary condition, it should offend the parts that were to be nourished. Moreover if the meat be not well mix'd with moysture in the stomach, (since there is no such moysture

moysture any where else, nor any such convenience for the mixture of it as in the *ventricle*, the fault of the first concoction will not be helped by the second.

But lest any one should think that this is done by drink, it is certain that it is likewise mix'd with this juice before it goes out of the *ventricle*, but that it need not so long time for it, because sooner and rather soft and liquid things are digested than grosse things, for being vomited up a while after it has been received, it appears thicker and more slimy unlessse the stomach be diseased, and be weak of concoction, then it comes out thin, and sour, because all that goes wanting that favorable juice, becomes sour, and is corrupted.

Most do attribute this sour juyce to the *milt*, truly without reason, since nothing is carryed from it to the stomach, neither slime, nor humor, nor acide spirit, to further digestion, or provoke appetite, or for any other cause; the reason is, because there is no way, nor no immediate passages from the *milt* into the stomach.

It is a hard thing to say whether anything be carryed from the *milt* to the stomach, I know that grave men, and of no contemptible judgment, doe think that the smaller portion of the *Chylus* does

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sinuate it self into the *Pores* of its *Tunicles* (after the same manner as they believe that the thin which is separated from the grosser left behind by straining it after its egress, is admitted or received by the membranes of the Intestines and the *meserick veins*) and that it is drawn together by the blood returning, it is led through the small branches of the *Gastrick veins* into the *milt*, and mix'd with the blood passing out of the abundance of *arteries* in that place into the *veins*, and mix'd with the heat of the said *milt*, and then that it flowes through the splenick passage with the Hemorroidal blood into the *vena porta* and the *liver*.

These things, since they are obscure and not apparent, I neither dare give credit to them nor contradict them. The *tunicle* of the stomach seems to be so much taken up in emitting of moisture, that I do suspect that it cannot serve two motions so contrary, to send out of the *pores* of the *tunicle* into its hold, and out of its hold into the *pores* of the *tunicle*, at one and the same time, especially since it stays to be chylified there.

It proves nothing that in a living creature, tying the *veins* which go to the *milt* they swell towards the *milt*, for this is common to all *veins* which are tyed, to fall towards the roots, and swell towards the branches.

As

As to that, that the *gastrick veins* are grafted into a branch of the *splenick*, and whilst it is as yet in the *milt* hid, but the blood which is sent through them does not touch the substance of the *milt*, only it is mix'd with that which comes out of it, and with a quick motion it is carried into the *porta* to dilute the *chymus*, which there it meets with, coming out of the *glandules* of the *mesenteric*.

I do think that the *milt* was made for this use alone, though more attributed to it by most learned men, and prime Physicians, that it may deposite into the *porta* that blood which it receives in abundance from the branch of the *caliac vein* (neither does it receive any thing besides blood, nor any thing from any other part) being first strain'd through its thin and spongy substance, that it may there dilute the *chymus*, which is but little in regard of the blood which flows to it, with abundance, together with that which returns from the nutrition of the rest of the bowels, which is so necessary, that when the *milt* is obstructed, and the passage of blood is stop'd, and the *chymus* is not well diluted, the whole body by deprivation of the nutriment is extenuated, and the *milt* swells into a greater and more troublesome bulk by the restagnation of blood.



## C H A P. III.

The use of the *Vena Lactea*; what is the use of the *Pancreas* and *Glandules* of the *Mesenterie*; the *Chymosis* is the ruder part of sanguification begun; what *Chymus* is; the preparation of blood in the *jecur Uterinus*; the order of nature in nourishment.

**A**FTER the *chylus* is let down into the *intestins*, that which is grosse is always mov'd further by a *Peristaltick* motion, but that which is thin is squeez'd through their finer body, being diversly perforate by *arteries* and *veins*, as well milkie as ordinary ones.

These *vena lactea* opening themselves the middest of the bowels (especially the biggest of them running out in length through the middle of the *pancreas*, with a manifest and open mouth, which it has in common both to it, and the biliary passage) do receive this same being white milkie into them, and then endeavouring to free themselves from distention, the others do move it forward to be received in the *glandules* of the *mesenteris*, and is into the *pancreas*. This is manifest to any body, who with diligence and attention does observe in the opening up the  
ab-

*abdomen* of a living dog so that you need to believe no body but your own eyes.

The *pancreas* or *callicreas*, called by some the *pandenon*, its called the *laetes* by some for its whitenesse and softnesse: is a fleshie body, made or plac'd near the first joynt of the *loins*, three or four fingers broad, lying from the *milt*: length under the hinder part and the bottom of a mans stomach, and is stretch'd out lying upon the *reins* near to the *intestinum duodenum*, and the concavities of the *liver*; Besides its glandulous and fleshy, it has a *membrane* with which it is cover'd, *arteries* from the *celiac*, which are joyn'd to the *porta*, and *nerves* it which spring from the sixth pair; It has likewise a passage through its flesh diversely distributed and divided.

The greatest of the *vena lactea* draws hither with that great opening which has common to it, together with the biliary passage, begins here very manifestly from the *intestinum jejunum*, and stretch'd out according to the breadth of the body & length of the *pancreas*. It is as big as a goose quill: in a dead corpse it is open'd, it has nothing in it like the tubes of the *laetes*: all which notwithstanding by reason of their smallnesse, and because they are so like the *membranes* that uphold them, do vanish and cannot be



by us; but here by reason of its bignesse, and because it runnes along the flesh, from which it is easily discern'd, it is conspicuous enough; in a living creature, open'd some hours after repast, it is swell'd, being full of white juice; being bound with a *ligature*, it swells most towards the *intestinum*, but beyond the *ligature* it is presently empty.

For what end I beseech you? that it may become a nutriment to the *Pancreas*? Not at all: For this moisture is not fit for nourishment; and then the *Pancreas* has *arteries* from the branch of the *Celiac* fit for that business, yea far greater than the small quantity of it requires, which is an evident token that they serve for another use, and for a greater, that is to say, the common good. For the milky juice deposited in its soft and spongy flesh, being with the blood (which flows thither in great abundance for the cause aforesaid) mix'd & humbled, and having acquired the colour and the consistence of it, is carried into the *veins*.

We may think no other wayes of the *chylus*, having pass'd by this opening, out of which the *Chymus*, is squeez'd by the forcible contraction of the *intestines*, and the compressive weight of the *bowels* lying upon it, as also by the continual motion of the *muscles* of the *abdomen*, & is receiv'd by the *vena lactea* to be deposited in the

Glandules, whence being turn'd into blood in manner aforesaid, it enters into the *capillary veins*, out of which sliding, it is diluted by great store of blood flowing ever where from the *vena porta*, but especially from the *Milt*, destin'd to that use.

This is the more imperfect preparation of blood, which (if for its rednesse deserv'd in any case the name of blood) is to be called *Hematosis*; but because it has not as yet gain'd all which are requisite to the constitution of blood, but onely the first disposition, it is rather to be called *Chylomatosis*.

*Chymus* is the earthy and dry part mix'd with moisture, or the strain'd juice of them by the mediation of heat; such may that matter be said to be, which is contain'd in the *Vere Lactea*, and is separated from the grosser substance of *Chylus*. But because this is taken by the prime Physicians for the *Chymus*, in being separated from the *Chylus*, and continuing in the *Meseraick veins*, it is (as we say) dyed by the *liver* with a crimson colour; We do likewise think that this matter, after it is pass'd the *adenes* of the *creas* and *mesenterie*, and receiv'd into the little branches of the *vena porta*, may be called *Chymus*: For as by the mixture of things drie with moisture, a taste, or rather that which has a taste is made up; so like



out of the thinner part of the *Chylus*, being diluted with blood, the *Chymus* or saporie juice is made fit to be wrought into blood, being equal to that red *chymus* of the *Antients*, which is in the *veins* of the *mesenteric*.

To this *Chymosis* answers that preparation of the blood in the *Placenta*, or *liver* of the womb, whilst the birth is as yet in the womb, in which a juice descending from the body of the womb, (for it slides down like the white of an *EGGE*, not in the form of blood, which both ocular testimony, and the disposition of the vessels demonstrate; for that of the Mother reaches not beyond the womb, that of the Child not beyond the *Placenta*) is diluted with blood brought through the *Umbilical Arteries*, both for nutrition, as likewise for the performance of this work, and is mix'd, and acquires the first disposition of blood.

The industry of carefull Nature in this admirable; for like a good Mother being solicitous of the sustaining of the life of the creature, receiving first into the *matricle*, she mixes it with a little mixable juice (little in regard of that which comes after) into a thick, but soft mass, from which a convenient and more fit portion, by expression, as it were through a strainer, being separated, she throws out the dreggs into the Draught.

These being preserv'd and purifi'd  
white as milke, in the *Adenes*, with  
blood powr'd to it, she labours it and  
moves it up and down after the maner  
of our Apothecaries or Cooks, with  
first pour a little liquour into that stuff  
which they are about to make a medica-  
ment or broth, the better to mix it, and ac-  
cording to it the relish and the rest of the  
liquour, they mix all as it ought to be :  
likewise in the *adenes*, Nature pours  
more blood to that matter which was  
before diluted with blood, adding *choler* : a  
seasoning to it. But lest any thing should  
passe unmix'd, and should enter and  
file the chamber of the body, be-  
sifted through the small and innumera-  
ble windings of the *liver*, it is at last mov'd  
forward into the *vena cava*, to be  
mix'd to the *heart* with the rest of  
blood returning.

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CHAP. IV.

*Choler* the condiment of blood, and  
excrement of the *liver* ; The Symp-  
tom of the bladder of *choler* ; how *ch-*  
generated in it ; the necessity of



the biliarie passage it is carried to the liver, and by another passage when it is to be mix'd with blood; of the *Vena Porta* and *Vena Cava*; the use of the liver.

I Shall, perhaps, be thought to speak a Paradox, when I set down that the *choler* is added to the blood in manner of seasoning which was thought by all the Antients and Modern to be an excrement, (though profitable for the expelling of filth) as being contrary to the nature of Animals, which rejoice in sweet things, and are nourished by them: But I beleieve that the reasons which shall be brought will demonstrate it by ocular testimony, that *choler* is not an excrement of the liver, nor is thrust out from thence into the gall chest, but sever'd, by the membranous body dispos'd thereto, frõ the blood, brought to *cystic arteries* the originals of the *coeliac* branch into its proper hollow-ness, as a storehouse, that from thence, necessity requiring, it may be added to the blood, and help the *hematosis*.

The *choler* chest, the biliarie bladder, the gall chest, consists of a *membranie* substance, which may be contracted and extended; besides that which is common to the rest of the intrals, it has a strong tube of its own, strengthened with all manner of fibers; it has a round figure, yet

somewhat long, & at last ending in a longer point, which does make up a concavities inaccessible to the view; for it has but one passage or draught, open within, but shut without, for it is enclosed with *portals* giving egress to the *choler* going out, but altogether hindring the return of it.

To this are little *bladders* given, besides *nerves* from the *sextum par*, these are *arteries* and *cystick veins*, those springing from the branch of the *caliac*, those from the *vena porta*, those carry blood unto it, these carry that which is superfluous after it has done its work back again into the *bladder* of the *porta*, which all may take notice of by the motion of the blood, the nature of the vessels, by the constitution of the *portals*, and by adhibition of life in a living creature.

Besides these, although it has no nutritive parts, it throwes out the swollen *choler* (by which it is alwayes distended and full) either by being pressed, or contracted, or stirred up by the abundance of it into a passage which is joyn'd to it, which notwithstanding it neither receives nor could receive from any neighbouring or remote part.

The *urinary bladder*, though it close on all sides to one looking upon it, insomuch as blown up to the utmost extent of it it is not so much as pervious to



wind, yet it has *ureters*, in passages grafted obliquely into its membranous body, which carries the urine being digregated by the force of the *veins* from the blood; but this *bladder* has no passages by which it can receive any thing, besides the *arteries* which bring such blood to it as is contain'd in the vessels.

These things being prov'd, I believe it is to be concluded, that the *choler* is not the excrement of the *liver*, nor that it is separated from the blood by its segregatory force: because neither is there any place for its separation, nor is there any ways found by which it may be convey'd into the *bladder* after separation.

And again, since *choler* is not brought to this little *bladder* from any where else, nor any thing else besides blood (which the *arteries* do afford to it in great enough abundance) is admitted into its *unicle*; I believe that it is to be thought, that by the proper contraction of its own *unicle*, *choler* is separated from the blood, and is as it were by sweating through its *pores*, laid down into its *con-*  
*vitie*, and there reserv'd for use.

Let not I beseech you this seem wonderfull or imaginarie to any person; for does out spittle distil into our mouth; so does the innermost *tunicle* of the *ventricle* sweat out its moisture in the preparation

of the *chylus*; so is *urine* deposited into the bosom of the *reins*; so diverse sorts of matter is heap'd up in the little skins of the abscessions, according to the nature of the part from whence it did flow.

I think that this gathering of the *choler* into this *bladder* is from hence easily demonstrated, because it is in all creatures insomuch as it is proverbial, that the *Emmet* has her *choler* too: but let us see it followes of necessity that it is added to the blood according to the manner of its evacuation.

The narrow neck of this *bladder* stretched out in length makes up the biliary passage, call'd the *cholidocall pore*, these are plac'd *portals*, which besides that they hinder any thing to enter into the *bladder* through this passage, they hinder the return of the *choler* it self after once out: which appears when with our fingers we endeavour to squeeze back the *choler* which we have squeezed out otherwise by no means can it be thrust back again.

This passage is divided into two things, of which the one being first divided into two, then into more, and afterwards into many sprigs, passes through the strainer of the *liver*, that the *choler* being divided into very little parts, may be mov'd forward into the *vena cava*, passing through



through the *liver*, together with the blood which flowes from the *vena porta*. The other going further is obliquely grafted into the beginning of the *jejunum*, being drawn down betwixt both the *tunics* of the *intestines* about the length of two inches, so that it makes one hole in the *intestine*, together with that leading which runs through the *pancreas*, that it may mix the *choler* with the milkie humour, and give it to the *pancreas* through the foresaid passage, or being pass'd through the hole to the *vena lactea* to be prepared with the juice of the *chylus* being pass'd.

It seems to me absurd, yea impossible, that two liquours should meet without mixture, that the *intestines* should squeeze out the grosser, and the *vena lactea* receive it, and yet not receive that which is thinner.

It is fit that *choler* should be added to this insipid and sweet liquor, both that its sharpnesse and surpassing yellow colour, should be temper'd with this raw white and inconcocted juice in the *adenes*; as likewise that its dull, slow constitution should be excited and mov'd.

If the other, that is to say the passage which goes to the *intestines* be stop'd, or by external compression be so streightned, that the way of the *bilis* to the *intestines* be

be hindred, it so comes to passe that the colour and fierceneſſe is not appeas'd in the *pancreas* and *glandules* of the *meſenteric*, and therefore ( for by the toth passage it is carried in greater abundance into the *liver*, and from thence together with the masse of blood into the habit of the whole body ) an *icter* is caus'd, and the whole body turns yellow.

They that drink more enough ( for it goes out of the stomach sooner than meat ) than the effusion of this *choler* can mix with, their pisse is like water and of no dye: likewise we pisse whiter a little after meat, for which, the drink most part of it being pass'd, the quantitie of *choler* is more unequall, than when it moves forward the grosse *chylus*.

It happens likewise that those whose passage is stop'd for some cause, and the *choler* not exoner'd, but at some times, they pisse waterishly with no colour, but afterwards they pisse colour'd urine, the passage being open'd or exoner'd.

By these reasons and examples, I am perswade my self that the *choler* is not an excrement of the *liver*; but being made for a better and for a common use, it is first heap'd up in the bladder, and in its own time is both mix'd with *Chylus*, and bestowed upon the *liver*.

The



There meets in the *vena porta* a great quantity of blood sent from the *milt*, the *Chymus* having suffered some alteration in the *pancreas*, together with that which is prepar'd in the *adenes* of the *mesenterie*, and blood now made uselesse after the nutrition of other bowels, likewise that which flows thither from the *hemorrhoidal veins*, and at last some part of the *choler*, wch being only confus'd, & not duely mixd together, could bring no little harm to the body; which most wise Nature foreseeing, added the *liver*, by the inward part of which, as through a sieve, those confus'd things which we mentioned are renderd so small and so mix'd, that they are brought into one masse, which after this manner being made wholesome, is added to the rest of the blood in the *vena cava*.

For in the *liver* the roots of the *vena porta*, and a great many twigs of the great branch of the *cava* are stretch'd out, which passing through its strainer are at last joyned, and doe stick close together; so that you would say that they were a *vein* which had been divided into many branches before, and joyn'd together again.

This will appear, if you blow up the *vena porta*, putting a pipe into it, till the *cava* swell up: with ones very eyes these conjunctions may likewise be seen, if you take from a *liver* being sodden, all the flesh  
warily

warily with a comb, which being separated and wash'd away, the substance of the *veins* does open themselves very well to be seen, so that the small divisions and meetings may easily & exquisitely be discern'd.

It is therefore the function of the *liver* with the help of its own *veins*, being fenestrated with the *parenchyme*, to bring the matter elsewhere prepar'd (that is to say, the *chylus* and the *choler*, with blood for the solution of it, chiefly from the *milt* flowing) and the rest of the parts which are to be nourish'd, adding to that through the small *arteries*, the superfluous part of that which is brought for the nourishing of the *parenchyme*) into one liquor familiar to nature, which is to be added to the other mass of blood, without any delay or manifest concoction.

This some endeavour to prove from the branches of the *veins*, lurking in the *liver* and not conjoyn'd, (whilst they believe that there stays a part of the blood here to be attenuated) albeit they be only little *veins* answerable to the little branches of the *arteries*, through which, through all the rest, the blood passes with a sudden motion.

They doe affirm that the blood being alter'd with these divers mutations, and being mix'd with that in the *vena cava* which returns from the whole body, is as  
mentoon



mentary and fit for the nutrition of the body, who doe aver that it is distributed by the *veins* into the whole body; but seeing this assertion, as I think, is sufficiently convinc'd by the reasons of others, I shall not meddle with it.

A birth does likewise confirm this example, for in the womb it is nourished with such blood, when notwithstanding it is necessary for every thing that is born, not only to enjoy the free air, but likewise, without its admixtion blood cannot nourish.

## CHAP. V.

*That there may be a nutrition of the blood, two things are necessary; whence its mobility; What manner of blood the birth requires; what is the reason it comes forth; what is the use of air in the body; why an infant being stop'd in the passage of his excrement, or water, dies quickly; the blood of the veins unfit for nourishment of the parts; which way nutrition is perform'd; how much air is needed for nutrition; its divers effects in mixed things.*

**T**Hat the blood may be turn'd into nourishment for the body there are two things

things very necessary, mobiltie and something pressing it, by the help of which it may flow or be mov'd to the places which are to be nourished; since this does not depend on the blood, but is different from it as that which moves from that which is moveable, it contributes nothing to the *Hematosis*. Indeed this fluxibilitie or mobiltie pertaining to its constitution ought to arrive from the Sanguificative vertue and be reducible to the *Hematosis*.

Whey, or water, or air, that is mix'd with the blood make it movable, which this deservedly is called the first moistner.

I dare not number Heat amongst these. Hot blood sometimes atters in the body to wit, when it is out of the vessels; Cold blood does likewise flow in Fishes, and in the *veins* of dead Corps; and that which is drawn out of the *vein* into a bason many times remains fluid, which will be condensed in a thin earthen vessel.

Therefore let the two former suffice with this distinction, that by the whey and blood the Members are made flaccid and soft; by the aerial (for in the dissolution of any thing air is more easily separated & passes better away) the more solid parts are made more robust and more veget.

Although this be necessary for creature and needful yet for the birth whilst it is



the womb (both that it may pass through the parts that are to be nourished, as also that the conjunction of it being dissolv'd, that which is fit may the more easily be assimilated, and that which is hurtfull be separated and voided) yet the wheyish moisture being drawn from the Mother is sufficient for the augmentation and nutrition of the tender and flagging members.

But when it grows bigger, beside that Nature in requiring aliment wants air, it has likewise need of it to facilitate the motion of the *heart* and *brain*. For they are mov'd continually, and are exagitated by an alternating *Systole* and *Diafsole*; nor are they hinder'd by the birth being tender, for the whole breast with the *heart*, and with the *brain* the *cranium* it self cover'd with a film rises and falls again.

The members growing solid in time, the bones doe daily acquire more hardnesse, and are more resisting to the motion: In the mean time the strength of the body and the *heart* growing, the pulses and motions of the *brain* become greater; which discord going on, it comes to passe that the birth, instigated by a desire of freer motion, is incited to change place, and seek for air, and so the delivery is hasten'd.

The Infant comming into the World it  
is

is seriously to be observ'd, that the blood is moistned and made more subtle by the attraction of air, whence the excrements (which in the time of gestation were few) are augmented, and then the whey humor of lesse avail is voided in greater bundance; insomuch that it is seen that an Infant which is born without an ordinary passage for his urine or his excrements, is dead in a short time, ere ever he sucks or takes any spoon-meat, or at least after he has taken a very little.

I being taught by the consideration of these things, doe undoubtedly perswade my self, that neither this blood, nor any other which is contain'd in the *veins* (if it is thick and uselesse) is fit for the nutrition of the parts, unlesse being mixt with a due proportion of air, and enlivened it can be admitted into the very least parts of them; for nutrition is not made by a continuall addition, but when the nourishment is fitly added not only to every part, but duely to every little portion, and assimilated to it.

It is clear enough that this fluxibility is given to the blood by the air, which is the first moistner, being a moist body, because none is sent into the parts through the *arteries*, unlesse it is being cleans'd and purg'd from its unprofitable fumes, it be well wrought with



And again, because it is continually drawn without any delay, that it may be mix'd with the blood.

If any body say that it is only necessary for the motion and cooling of the *heart*, he is convicted by the example of fishes: For besides, that they are alwayes cold, they do alwayes draw up water at every pulse of their *heart*, and send it out at their *gills*, with which they might be both satisfi'd for the motion of their *heart*, and for refrigeration if they needed any such, yet to them is given a little *bladder*; in which they carry air along with them, that they may stay under water, not alwayes be forc'd to swim at top to take the air; for if being taken with a Net or Weel they be kept longer under water, and be hinder'd to take the air at last, the air in their little *bladder* being spent they are suffocated and die.

Likewise the great effects of the air confirm this, matter which may turn into stone, by reason of the combination of the air, being flowing like water, so soon as it comes out of the pores of the Rock it becomes as hard as a stone without the separation of any visible busines; The air being disjoyn'd by its own accord or otherwise easily knitting that which is round about it.

*So Coral branches when they touch the air  
Grow hard, under the waves soft herbs thib  
were.*

We see out of Mans body, that juices sicc  
out through little pores, which scarce pass  
sing the superficies of the body, grow  
thick and slimie, and unequall to the little  
pores frō whence they did issu, yet witho  
manifest taking away of any thing; whi  
I doe therefore think to be imputed to  
air insensibly separated from it.

## CHAP. VI.

*The opinion of Columbus concerning  
storehouse of the vitall blood; reas  
proving it; the frame of the lungs; a  
cerning the vein and arterie Pneumonia  
that this is not an arterie, nor that a v  
the vein and arterie in a Birth take  
rises from the ventricles of the Heart  
the cause of their Difference; the  
joynd to the risings of the veins are p  
thereof, not of the Heart.*

**R** *Ealdus Columbus*, a most famous  
anatomist, was first of the opinion  
the mixture of the blood with air was  
in the *lungs*, and that this blood was  
vital, in his Booke *de re Anat.* II. Ca



For considering the capaciousnesse of the *vena arteriosa*, by reason that it is too big for the nourishing of the *lungs*, he thought it was likewise appointed for some other use; then because the substance of the *lungs* cannot subsist without vital blood, and it is found to be in it, in the mean time for that blood which is cast up by coughing out of the *lungs*, comes up of a fresh colour thin and fair, such as the Physicians do affirm the vital blood to be) he argues in this manner: If the vital blood is not given from any where to the *lungs*, it is created in it, but it is not given to it from any where else; for it has no branch from the *aorta*, nor by the *arteria venosa* (which for the fabrick of its *portals* receives no blood from the *heart*, for if it did, it would beat) does it receive any thing; therefore, &c. It does likewise follow that it is bred there, since live dissection does demonstrate that the *arteria venosa* full, not of blood, but of fumes and scum, and is without pulse, which proceeds from the *heart*.

Being confirm'd with these reasons, he says; (ye shall hear his own words) He takes in the air by his mouth and nose; for it is carried to the whole *lungs* by the conveyance of the *Arteria Aspera*, but the *lungs* mix the air with the blood, which coming from the right ventricle of the heart is

carried through the *Vena Arterialis*. This blood is driven up and down by the continual motion of the lungs, and made thin which likewise in this breaking and justling one with another is prepar'd: That blood and air being mix'd together may be taken in through the branches of the *Vena Arterialis*, and at last may be carried through the trunk of it to the left ventricle of the heart; but they are carryed thither so well mix'd and attenuated that there is but little work left for the heart.

It is credible that the blood gains this perfection, where the greatest convenience and occasion for the gaining of it offer'd: But there is alwayes air ready in the lungs, and a convenient composition. For their flesh is soft, light, thin, spongy, so interwoven with three sorts of vessels, that it is rendred full of holes like froth or a sponge.

The vessels are the *Pneumonick vein* and *arterie*, and the *arteria aspera*, the use of which is easily known from the following relation.

The *Pneumonick arterie* (being wrongfully styl'd the *vena arteriosa*) rising from the basis out of the higher part of the right ventricle of the heart, scarce enters the lungs (a little above that long passage which is open in Children, but clos'd in those of Age, by which it being join'd



stand inseparable from the *arteria Aorta*, (shews the conjunction of both) but it is divided into two branches, of which one goes to the *right*, and the other to the *left*, both of them being again cut in two, which being divided into more it is spread in very small branches running through it all, even to the utmost of their substance, and contributing blood to this work.

To these he answers, That vessel which is dispers'd through the same substance with many divisions of branches being communicated to none of the intrals, called the *arteria aspera*, which is a long pipe, being made up of semiannular gristles called *Bronchia*, and *membranes*, joyn'd together, always lying open to the air, beginning from the lower part of the jaws, first leading on the *oesophagus*, afterwards being divided likewise in manner aforesaid, and dispers'd through the substance of the *lungs*, and being joyn'd to the very branches of the *Pneumonick arterie*, adds air to the blood for this purpose, with which, by the motion of the *lungs*, being stirr'd is mix'd perfectly and made thin, that the fumes and the grosser excrements, (of which this is expectorated by coughing, and the other by breathing) might be separated and let down into the *Bronchia*, and that the blood might passe through for the nutrition of the *lungs*, and

enter the small branches of the *vena pneumonia*.

This *vein* is not only alike in substance and in constitution to the *vena cava*, but also joyn'd to it, so that without rending it cannot be dis joyn'd, being not well call'd by the name of *arteria venosa*; it risse from the top of the *left ventricle* of the *heart*, the beginning of it being fleshy and broad ( called an *ear* by reason of its resemblance, and the *left ear*, because of the *left ventricle* to which it is joyn'd) hollow because contracting it self like a *Spincter* it lets out the blood being collected in the *ventricle*, as the *vena cava* does on the *right side*. This accompanying the *arteria*, and being divided after the same manner, ( together with the *arteria aspera* ) it strai'es through all the parts of the *lung* that, like the rest of the *veins*, it may carry the blood which it receives in the *capillary veins*, and other its branches, into the *great Trunk* of it, and so at the contraction of the *ear*, every time when the *heart* is at rest, let it into the *left ventricle*.

In a birth this businesse is far otherw<sup>e</sup> to whom, since the wheyish humour, that which is made flowing by the air, and the little air which it receives from the *Mother* ( as was said before ) is sufficient for its tender and soft members, the use of the *lungs* is at rest; There both the *veins*



*tricles* of the heart, with one motion as it were ( which only creatures have which want *lungs* ) serve to move the blood out of the *veins* into the *arteries*.

For Nature being forc'd for an use to come to frame two *ventricles*, gave a beginning both to the *vein* and to the *arterie*, that it might thrust out the blood received by both, through both into the *arterie*; Hence it comes to passe, that as the *arterie* takes its rise from the *right* and the *left*, a *vein* likewise arises from both its divers beginnings tending to one end; yet so, that a branch bringing blood from the dexter rising of the *arterie*, and returning that which is superfluous from the left rising of it, shall come to the resting *lungs* ( for they ought to be nourished ) which when the *lungs* grow greater, and doe execute a greater function, growing to be bigger, surpasse the *Anastomosis* much in largeness; and the rather, because those passages which were common, becomming afterwards unprofitable, when the Child is born ( that is to say, the *arterial passage* and the *oval hole* ) are not only obliterated, but leave off to grow; yet are they not so much changed, but that their passage, being like a great *ligament* shut up, shew clearly enough the conjunction of the *arteria pneumonica* with the *aorta*, and of the *vein* with the *cava*, being onely

clos'd with a little *membrane*.

*Veins* do differ in this from the risings of the *arteries*, because these are enclos'd with a large and moveable appendix joyn'd to the *heart*, They call it an *ear*, with which it is cover'd as with a *spincter*, of which the *right* far surpasses the *left*; the cause of this perchance is, (for whilst the blood is violently driven towards the *heart*, being hinder'd by the operation and contraction of this, it violently distends the *ear*) because all the motions and contractions of the body are more violent than those of the *lungs*.

The *ears* are rather parts of the *veins* than of the *heart*, because they have a cavity common to both, but they are separated from the bosom of the *heart* by *portals*, and then they are given to the *veins* alone and to no other vessels, in whose substance they with fleshy *fibers* cut out a little; besides, the motions of the *ears* are distinct from those of the *heart*. These things I thought fit not to be admitted, because they give way and lighten the search of the truth of the question at hand. There are likewise other parts, besides the *lungs* aforesaid, which do immediately assist in the *Hæmatosis*, because by freeing the blood from things unfit and hurtfull, (namely the *residuum* in the bladder, *intrails*, the *skin*, the *palat*,  
inw



toward *tunicle* of the *mouth*, the *ears*, *no-*  
*strils*, *eyes*, &c.) which are so plac'd, that  
taking that which is most alike to them  
from the blood which is brought for their  
own nourishment, the rest which remains  
profitable they doe let down into the  
*veins*, and do discharge that which is un-  
profitable either into their own bosoms,  
or into the circumference of the body; but  
because the relation of them would be te-  
dious, desiring brevity, I shall omit  
them.

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C H A P. VII.

*That the Blood ought to be mov'd to the pla-*  
*ces which are to be nourished; when, and*  
*how life begins; a Bubble turns it self*  
*into an Ear, and the Heart comming to*  
*the assistance of it; The situation and*  
*composition of it; what instrument of*  
*the Soul the Heart is.*

**W**E said even now, that there was  
requir'd some impulsive, that the  
blood being now moveable, and absolute  
at all points, might be mov'd toward the  
parts which are to be nourish'd. For the  
nature of blood and ocular testimony doe  
confirm, that blood flows not thither of  
its

its own accord, nor is it attracted by its parts, (for all heavy things tend downwards) How this begins from the very first life of the creature, and continues in its life time (adjudg'd so to be by a diligent searcher) I intend to relate.

Life seems to begin and to take its first rise, when after the first disposition of the creature, a little moisture, by the help of heat gathering together things homogeneous, and separating of the heterogeneous creeps into that part which begins already to be firm, and so representing the beginning of a *vein* raises that into a bubble or little bladder, which first resisting and afterwards contracting it self, shakes the moisture into the raw beginning of an artery; this returning back, and the little bladder contracting it self again and again the motion, after the rude shaping of the members, growing greater, the parts receive nourishment and more perfection and this liquor acquires the colour and consistence of blood. Out of which while the encrease of the fleshy part grows fast to the little bladder, now receiving the form of an *ear* (which to some creatures is sufficient all their life-time) the flesh grows up, together with the first beginning of the *heart*, which as a help to the *ear* is created for the better propulsion of blood.



For this function as was most fit, it is not plac'd in the middle of the body, where according to *Anatomists* the Navel is placed, but in the breast, a place nearer the heart, that it may more conveniently furnish it with blood, which of its own accord flows downwards, as also that in it being environ'd with the ribs, it might move closely within the *pericardium*.

The flesh of it is hard, yet so that it may be contracted, being of grosse workmanship, just so (if in little things we use great comparisons) as a pillar made of *Toscan* workmanship, which being clownishly made, is put as a prop for bearing the weight of the house; so this lump of flesh is given to Man by Nature, that it may be able to endure the labour to which it is destin'd by Nature.

This flesh has two bosomes, namely, the *left* and the *right*, of which one because it only drives the blood into the *lungs* which are near it, has not so thick walls, and grows as it were into the right side of the heart, but the *left* because it distributes blood into the whole body, is environ'd with much thicker flesh.

To these receptacles answer their vessels common to them, being fenced with *portals*, namely the *veins*, with their appendices or *ears*, and the *arteries*, of which these are open without and shut within, but

but the *arteries* are open within and without, having 10 open *orifices* that they evidently show that the quantity of blood which passes through them is small.

It has besides these no ordinary vessels either bringing or carrying away, which are fit for that work, onely the small *Coronary arteries*, rising from the *aorta* before it goes out of the *pericardium*, are grafted into the *basis* of it, with their *conjugal veins* which rising from the *cava*, so soon as they pass'd the *heart*, are communicated to the *basis* thereof, that they may gather up the superfluous blood, and restore it to the *vena cava* to carry it back to the *heart*.

Being so fram'd, it hangs in the bosom of the *Pericardium*, only in the *basis*, or the parts which are broader than the rest (by the mediation of the *Pericardium* and other vessels which arise from it) it is tyed in the middle of the *thorax*. The rest of its body from a broad rise like a cone stretching it self forward towards the right side into an *apex* or point, and swimming in the water of the *Pericardium* which facilitating its motion, is every way free.

Hence it is, that when the *heart* is in action, which is perform'd by the contraction of all the *fibers* together, the free point is drawn towards the immoveable

body



bottom, and so is lifted up, and making a heap as it were, strikes the brest with a pulse which is felt outwardly.

I do therefore conclude, since the parts do acquire apposition of nourishment, and that no part besides the *heart* has the convenience to doe this (which is evidenc'd by the agreement of the vessels, the connexion of the *ears*, the disposition of the *portals*, the vastnesse of its fibrous and contractible flesh, its fit place, the due composition of all things, and the protrusion of blood in creatures living apparent to the eyes) that the *heart* is the instrument dispersing the blood receiv'd from the *ears* into the *arteries*, by the subserviency of which, it furnishes nutriment to the whole body.

Those who are more taken and blinded with greater esteem of the *heart*, are not content with this use (the which to gain-say, is to deny credit to ones senses) but they say that it performs many more and better offices, and will have it to be the author and efficient cause of all heat and life; and because this is thought to be perform'd by the help of *spirits* and life, they think it to be the very warehouse of *spirit* and life.

## CHAP. VIII.

*The Arguments of Conringius for the Effluvia of the Heart, and the Confutation thereof.*

**A**Lbeit from the preceding Narration Reasons may be drawn, from which the evidence of the contrary may easily be demonstrated, yet I cannot rest satisfied if I give not answer to the most famous man *Hermandus Conringius*, Professor of the University of *Helmstadt*, a man much to be esteem'd, which he brings for the *Effluvia of the heart*. I shall not be unwilling to repeat them in the same order that I took them in out of his *Lib. de generatione & motu. nat. Sanguinis, cap. 24.*

I. 'Tis granted that the Heart is the beginning of the Arteries; and that the Veins are deriv'd from the same beginning, eyes doe sufficiently witness, therefore the Heart is likewise the beginning of all blood and the storehouse of it.

II. The fluxion of all blood to the Heart and the flowing of it from the Heart (neither does the blood goe to any other part or Bowel, nor does it all of it flow to any other part) but all motion is appointed for the obtaining of good, and therefore the blood gains its chiefest good in the Heart.

III. *M...*



III. Moreover the Heart is generated first amongst all the rest of the parts, and does both beget and contain blood, no other bow-  
el being as yet form'd, as it may be seen in eggs after the second or third dayes sitting, and it is approv'd by the authority of most learned men; and this comes to passe by a most certain rule, that the Heart out of fit and dispos'd matter can make blood without the help of any other of the bowels, yea that the first blood of all, of which the parts of the body are made, and which is so exquisitely elaborate, is concocted only by the Heart.

IV. It is likewise known that blood is generated in some, if the Heart be strong, though the Liver and the Milt be corrupted, insomuch as it is able to recompense the fault of the Liver and the Milt by its heat; as likewise any passion about the temperature of the Heart, doth cause that the blood of the whole body is either well concocted, or otherwise. Therefore by this alone we are able to gather the strength and ability of the Heart in generating of blood.

V. Its aptitude for nourishment is gathered from hence, that no part of the body is nourished but by blood, elaborate before the Heart; only in a birth that blood which is the matter of the parts is first seen in the Heart, and the very streyner of the liver in proceffe of time is generated from  
hence:

hence. In vain is all that nourishes first labourated in the Heart, unlesse by the working the blood be better prepar'd, than may be the fitter for nourishment. It is likewise certain, that that blood which flows from the Liver, often, if not alwayes, is raw, that it cannot be fit for the nourishment of the parts, neither is that again concocted by the Liver, or remains unfit for use, therefore it is taken by the Heart, that it may be made fit.

VI. Because all the heat of the creature is from the Heart alone, it is not to be doubted that the last perfection of the blood is from the Heart, and that therefore the Heart is the prime Storehouse of blood.

I. As to the first, I grant that the veins and the arteries doe arise from the heart, but it does not follow from thence, that the heart is their efficient beginning, nor I beleieve that it is the mind of the Author that one part has its existence from another, seeing all of them receiving their direction in the beginning, doe acquire their perfection in time.

Nor doe I believe that it will be maintained by him, that the blood is made the cause of the veins and arteries, but that they were made for it, ( that they should be vessels for conveyance, and not vice efficient )



efficient) nor that he concludes thus, *That which is the efficient cause of the veins and arteries, is likewise the efficient cause of the blood:* but rather taking his argument from the consequence ( for there where the beginning of the *veins* and the *arteries* is, there was the first necessity of them, which is for containing of blood ) *Where first veins and arteries are found and have their beginning, there first blood is found and has its beginning, and that is in the heart.*

*Answ.* It does not follow, that there where first blood is to be seen, that there it has its beginning, as if he should argue, from the beginning of the Trunk spring the roots ( if we may use this comparison, the *veins* are the roots of the body ) therefore they are the juice of the tree which nourishes it.

Blood, as I take it, begins from an invisible beginning, for a juice which is answerable to blood does meet together out of the first beginning particles of the creature through the pores, which are the first achievements of the *veins* or blood rather, agreeing with those parts whilst they are yet tender: This by its extension makes it raises a little bubble or bladder, which in time puts on the form of an ear, and stirs the *Diastole*, and gives it occasion first of assistance, then of contraction; for the

*Diastole* is before the *Systole*; for how shal any thing contract it self which has not first suffer'd the extension of the *Diastole* gent?

Whence it follows, that the concurrence of blood from an invisible beginning, is the efficient principle of this little bladder, and not the bladder of the concursion of the blood; as the many rills that meet together doe make up a river, and the river does not make up the rills.

Therefore it is manifest, that although the beginning of the *veins*, and their apparent rising be from the *heart*, yet therefore the blood does not rise from the *heart* but flows to it. That which is first in degree may be call'd the cause of the consequence but not on the contrary.

In an egg, before the *heart* be formed there appears first a bladder beating which being dilated by the blood, loses its red, and contracting it self layes down its redness, grows again white, and disappears which is a sign that the blood is before the bladder, ( which becomes an *ear*, 1<sup>st</sup> *heart* ) and that it grows red by blood, and that the blood does not grow red by the bladder.

II. This confirms what is said; because the blood flows to the *heart* it is clear that it has its beginning elsewhere. I leave to answer, that the blood



no sooner to any intrall, than to the *lungs*, and that it does not flow from any place more perfect and absolute at all points, then from the lungs, both reason tells us, and ocular testimony confirms it.

A Birth to which wheyish blood is sufficient, needs not the help of the *lungs*; nor does it need the *heart* for the change of it, so that it may only enjoy its dispensative motion.

The blood does not move towards the *lungs* but to be purified: If a creature arriving to growth, and having much blood could want them, as well as he does when he is in his Mothers womb, they had not been fram'd for a future use to the birth.

This purifying is perform'd not by the intention of the *lungs*, but by the action of the soul: parts being laden with blood move it further, either by contraction, or their own weight, or by resistance, that they may be free'd from it; so the *heart* by the impulsion of the *ear* being fill'd with blood, even to distention, moveth it forward, that it may be freed of the trouble of it.

Therefore the motion is designed for the good of the part moving, and not always of the moved; which in excrements is apparent: but parts do not act for one anothers behoof, but for their own convenience, they receive such things as

are convenient for them, and drive away such things as are hurtfull. But in this number is the *heart* comprehended, whose intention is not when it thrusts the blood into the *Aorta*, to give nourishment to the parts, but to put off a trouble which comes upon it self; besides it is the office of the souls government to give nourishment to every part, the organs being rightly disposed.

III. Although all the parts have at first an obscure delineation, yet there appears at first a little bladder which beats, which in process of time becoming more fleshy attains to the form of both the *ears*, therefore if any thing deserve to be said to be born before the rest, it is the *ear*, which is generated before the rest of the parts which moves first of all, and leaves motion last of all; and not that fleshy part of which the *ventricles* consist, in whose flesh they place all motion, and in the disposition whose *receptacles* they place all power, and the fountain of all faculties, although the very same motion be divers from that which is seen in an *Embryon*, and in the egg, and is only in consequence of it.

But neither does it generate the blood but receives it flowing from the whole body, by which it self is likewise made.

IV. Tis certain, that the *liver* or



*milt* being corrupted, but not beyond their bounds, good blood is generated, or else such as is not altogether bad. Nature does at sometimes endure the small default of one part, the rest being all entire, without great damage; but the *liver* or the *milt* being quite corrupted, I doe not beleieve that the body or *heart* can be so whole or strong.

It is certain, that the *milt* being obstructed, because the blood coming from thence is not well diluted, that the *heart* is troubled with beatings; and also those evils which affect the parts which serve the whole body, use to be hurtful to the whole body.

When there are more assistants in an operation, and one or more of them are diseased, if the whole is not abandoned (it is perform'd faintly and imperfectly,) this is to be imputed to the rest of the parts which are whole; it is inconsistent to attribute it to the heart, since it is certain, that its aid is not as yet requir'd to the sanguification.

It is hard then to assert any passion about the temper of the *heart*, to be the cause that the blood might either be well or otherwise concocted, for indeed there are many parts by whose perverse disposition the whole *Eucrasie* is overthrown, if they are combined together:

What hindereth, I pray you, the *heart* being ill affected . that the *lungs* or *liver* parts which belong to the *Hematosis* by the nearnesse unto it should be infected also? It hapneth often howsoever, that the temper of the *heart* is often vitiated by the ill disposition of another part, so that the affections of the *heart* are only the Symptoms, but not the Cause of the disease. From what offended part, the action it self is hurt, from the same it perform'd.

V Its granted that no part is nourished unlessse the blood passe the *ventricles* of the *heart*; and I doe beleieve that no man denies, that the nutriment is elaborated that it may nourish the better; so it is likewise true, that in a birth there appears first blood in a little bladder, and afterwards the *Parenchyme* of the *liver*, yea the *ventricles* of the *heart* in proces of time is there likewise generated; but by what argument taken from thence it will be prov'd that the blood either in the *receptacles* of the *liver*, or in the *ventricles* of the *heart*, is in any way elaboratly alter'd, or gains aptitude to nourishment, I see not.

Nor does that much presse us, that the blood has often flow'd out of the *liver* and is made fit by being concocted in many iterated circulations, and being purged from its dregs, nor has it any need to



re concocted again in the *liver*, or perfected in the *heart*, only it is necessary that by its said, after that it has received at every turn a new refining in the *lungs*, it should be driven into the *arteries*.

VI. It is true, that from the *heart* all heat comes to living creatures, not because it is hotter than the rest of the bowels, but by accident, this heat is rais'd in the parts through which the blood suddenly passes by its motion: which is an evident token that the blood receives not its perfection from heat, and so the *heart* is not the first storehouse of blood.

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## C H A P. IX.

*An instance given upon the aforesaid Answer taken out of the Method of Cartesius; why the blood of the veins is more thick than that of the arteries; the heart is not the Organ of Sanguification, neither can the consummation be imposed to it.*

For an instance to confirm this Answer, that shall serve which a most famous & renowned man *R.D. Cartes* brings for the proof of his fire, which he saies was made by God in the *hearts* of creatures, being

the Author of all motion and action, and likewise of the circulation of the blood method. page 47. The difference which is observ'd in the blood which passes out of the veins, and that which flows from the arteries, can rise from no other reason than this, that passing through the heart it is rarified, and as it were distill'd, and so becomes more subtle, lively, and warmer, so soon as it comes out from thence; that is to say, when it is in the arteries, then it was before it enter'd into them, that is when it was staid in the veins: And if one take good heed, it will be found that this difference does not manifestly appear, but near the heart, but lesse in places distant from it.

The most famous man assumes, that the arterial blood is thinner than that which is contain'd in the veins; nor without reason, for that which is in the veins growing uselesse, has lost some portion of its aerial substance, and that perhaps which it has retain'd is more full of fumes and duller, and retains not its former limbernesse; to which add, that some portion of the liquor is voided by insensible transpiration, as likewise it is sever'd and thrown forth by sweat & urine; if it receives any grossness in the outward parts, but is refrigerated, I am confident it deposits that grossnesse together with the coagulable before it comes to the heart.



Granting that the *arterial* blood is thinner than that of the *veins*, he denies that this *arterial* blood can become thin, unless it be rarified by the heat of the *heart*, & as it were distilled (we intend to speak of the heat of the *heart* afterwards) his reason is, because passing out it is always more subtle, lively, and hot, than when it enters. If the most famous man mean the entry of the first & out-let of the last *ventricle*, we do not grant that the consistence of the blood, yea the colour it self doth receive some change, but not in the *heart*, but in the *lungs*, for the reasons aforesaid: but if he speak expressly both of the egress and entry of them both, we deny that the blood does passe out of the *right ventricle* of another substance than it entered; nor will it ever be demonstrated, that the blood doth enter more thick into the *left ventricle*, than it comes out afterwards.

To call the *heart* the Organ of sanguification how absurd a thing it is, from hence appears, because it is not perfected by one part or instrument, but by many, for since it is fit that diverse things should concur in the constitution of blood, and be diversly wrought, as all ground does not bear all fruit, so cannot one part furnish so many diverse things, or is appointed to perform so many several operations.

If any body say, that the blood is only  
con-

consummated by the *heart*, I think he will be convinc'd by these arguments.

First because in the *heart* nothing is added to the blood, or taken from it; in the *ventricle* there is added to the meal and drink a liquor which sweats out of its *tunics* into the hold; in the *intestines* that which is grosser and unfit is taken away; in the *pancreas* and *adenes* of the *mesenteric*, a just quantitie of blood added to the *chymus*, which for the greater dilution is much augmented in the branches of the *porta*, by the subserviency of the *milt* and other intrals, that at last after the addition of *choler*, in the mediation of the *cystis*, it may through the *liver* by *Dadalian* windings perfect its course, and so being alike at all points make up one perfect compound.

No such thing happens to the blood without the help of the *heart*, since there is no administrative vessel which can either bring any thing to it, or carry away any thing which is separated from it.

I beleieve, that no man thinks that the *coronal arteries* and the *veins* joyn'd together do this, for they are lesser than can be employ'd in so common and greater work.

Authors which are prime Physicians, do to calculate very well from the largeness of the vessels, seeing some one part



ceive a great deal more then it needs for the administration of its nutriment; that such a thing is done for another parts sake, by Nature, which does nothing in vain: so let us argue, taking our proof from the smallnesse of them, that the *coronal veins* are destin'd to no other purpose, than for nourishing the *heart*; so much the rather, since it is certain that vessels are allowed to other parts, according to the same proportion.

If perfection were given to the blood from the *heart*, at least from thence it would suffer some change; but since there can none be perceiv'd, but such as the right *ventricle* receives from its *ear*, such does it unload into the *arterie* of the *lungs*, and such blood as the *left ear* likewise affords, the *left* gives to the *aorta*; certainly either the colour or the substance would show the change.

Those that doe ascribe the *Hematosis* to the *heart*, do affirm that there is more power in its *left ventricle*; but see what great absurdity would follow from thence, the *lungs* would be nourished with unperfect blood, for they doe not receive the least *arterie* from the *aorta*, or *left ventricle*; nor can they have any motion backwards, the motion of the blood, and the semilunary *Portals* hindering them.

Let it then be ratifyed and confirm'd,  
that

that the *ventricles* of the *heart* doe once afford a passage to the blood, which in *veins* and the *arteries* doe likewise, and that their flesh does drive it more forcibly for since the *veins* being weak could not impell the blood by the help of the *ears* into members far distant, the *heart* seems to have been added to them as a help, that being a great deal stronger, it might supply the defect of the *ears*.

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### SECT. III. CHAP. I.

*Whether there be a greater heat in the heart than the other Intrals; the reasons of Antients affirming it, are opposed; opinion of Cartesius concerning heat. What are the things that render this opinion plausible, both the composition of the heart, and reasons withstanding the first and latter motion of the auricle of the heart.*

**O**Rder leads us to examine our third Proposition, whether or no there is a greater heat in the *heart* than in other *intrals*. The Antients do so much appear on the affirmative part of this Question, that also the Philosophers of this age, that have made it an axiom it is not call'd in question by a



and as money is commonly valued at an even rate, with that which is best known: must so they do all build unanimously the preheminance of the *heart*, and principally of it upon this, as upon a firm ground, and very well known to all, above all other parts; and upon the same all the powers granted in all former ages, and even in our times.

*Aristotle* in his Book of Youth and Old age, Cap. 4. sayes, *That the beginning of heat depends upon the heart, and that the soul is as it were set on fire in that part.*

*Galen* in his Book of the formation of Birth, Chap. 3. sayes, *That creatures received the heart as a fire for warmth.* They commonly doe aver, That from hence the heat, through which the body of an Animal seems hot to the touch, is spread through the whole body.

But touching can give judgement as concerning heat; nor must you refuse to trust it, since it returns report concerning its proper object; the breast of a living creature being open'd no such great heat is found by touching, nor by search is it found greater than that of the rest of the animals.

Physicians judge as far as they can by sense, and that which is not to be perceiv'd they judge to be nothing at all; is not a greater heat denied in the *heart*, because it is

is not perceiv'd by the touch? we must re-  
infer that the skin of the hand is too thin  
or that it is colder, for in a little time  
that would be known; for those that  
very cold do not suddenly feel the heat  
of a good fire at first, which afterwards  
they are not able to endure.

We must likewise take notice of the sit-  
uation of the *heart*, whether it be fit  
for such heat: there ought to be an apt ob-  
ject answerable to a powerfull agent. fire  
is not fit to endure such heat, if the  
metals should boyl out of it, it might  
easily rosted or boyl'd; oyl is not enough  
in a lamp, but there is likewise a wick  
quir'd which may subsist and continue  
the flame.

This heat in the *heart* is either imbu-  
ed or acquired, this would quickly be dis-  
sipated and extinguished by the adven-  
titious juice, for nothing could be added  
that were so hot, for by the *heart* it ought  
to be heated, as fire by kindling, and  
agents must needs endure the reaction of  
their patients, by which it is at last in-  
creased; and it is likewise known, that white  
clay affwages that which is  
hot.

This adventitious heat must come  
from some other place, and from where  
pray you? shall it be sent from a part that  
lesse hot? or shall it be sustain'd by



nour food? the *heart* receives no other thing for its nourishment than that which comes through the *arteries Stephaleides*; nor is their blood any other, than that which is afforded as nourishment to the whole body.

Perchance it might stir the like heat, or a greater in other parts, for there are other parts fitter for the conception of heat, as being dryer, and heat is the more intense, by how much the thicker the substance is in which it has its residence.

*Renatus de Chartes* a most famous man, whose wit I do not only admire, but also much esteem of his Philosophie, *lib. method. pa. 42.* says, that the Almighty did place or stir up in the *heart* of man a heat or not shining fire, (not unlike to that by which hay is set on fire, when it is put on reeks before it be dry, or as new wine left upon the lees seeth's up) which exercises all the actions of the body, but thinking, which amongst all other creatures he gheffes to be only proper to man, as proceeding from his reasonable soul.

He sayes that the drops of blood which fall into the *receptacles* of the *heart*, are presently inflated and dilated by this heat like other liquours when they are let fall drop after drop into some vessel, which is excessive hot) whence he avouches, that as well the *arteries* (for some he says falls

into the likewise at the same time ) are lifted up together with the walls of the *heart* and that the three pointed *portals* in the middle are open'd , and that over all the *Diaſtole* is stir'd up ; but that the blood falls again , because in the *arteries* it is cooled , and that the foresaid *portals* are shut . and that there is a *Systole* brought upon the *heart* , as well as the *arteries* and that the *Sigmoides* or *semilunarie portals* are open'd , that make free access to new blood.

He says that this motion of the blood must necessary follow from the disposition of the organs, which we see with our eyes by heat which to the fingers is perceptible and from the nature of blood which we may know by experience.

This axiom has pleas'd many , truly it is more plausible to gather the cause of motion in creatures from things evident than to have our refuge to the Soul whose nature we are forc'd to confess we are ignorant ; besides , that it is evidently seen that the life of a creature is begun with heat , and is terminated by cold . But to say that the circulation of the blood is known from the disposition of the organs , perceptible heat , and the nature of blood , ( to whose judgement several famous men appeals ) if we will rightly weigh the businesse as in a scale , the



tion of the blood indeed is such and so circulatorie, but proceeding from a far different cause.

Let us see the disposition. There is given to the *heart* four vessels serving for the common work, two *veins*, and so many *arteries*, being fitted to the two *ventricles* the *right* and the *left*, to either of them there is allotted a *vein* and an *arterie*, and receiving the blood frō the *veins* they pass it in a like quantitie into the *arteries*. The *veins* are gifted with *appendixes* or fleshie baggs (they commonly call them *auricles*) endued with force of contraction, besides innumerable others, which they have for the better advancement of the blood, they have five *portals* in the entrie of the *heart*, which are opend of their own accord by the blood when it passes through, but shut their selfs against it when it endeavours to return; of which three are the *Sigmoides* of the hollow *vein* at the *orifice* of the *right ventricle*, and two are like half-moons shutting up the *orifice* of the *Pneumonick vein* from the *left ven ricle*.

The *arteries* have in their passages neither *portals*, as being unprofitable (for their action is every where the same, for they are all dilated at the same time, and all at an instant tending to their former constitution, are contracted at the same time, or lag by reason of some weight that presses  
○ them

them outwardly) nor have they any *appendixes* or *ears*, but have instead of these the *heart* made fast to them, in the egress of which from both the *receptacles* there are likewise three three-pointed *portals* large ones, annex'd, which are shut the blood endeavouring to return, by reason of the contraction of the *arteries*.

The organs being thus fitly dispos'd,, indifferent judge with his own eyes may see the swell'd *ears* contract themselves and thrust out the blood contain'd in them, without the resistance of any *portal*; and that the *heart* from these swells, and rises into a *Diastole*: This being distended, and endeavouring to discharge its burthen, the *portals* affix'd to the *ears* are shut by the compression, which were open before, those which answer to the *arteries* freely giving way.

But because it is not necessary that both the *ventricles* should meet with equal force, the *right ear* deposits the blood to the *lungs* alone, which are neighbour to it; but the administration of the *left* finishes the whole body, and gives it to the furthest parts, and at the greatest distance and even to those which resist it.

Hence the disposition of the *heart* invites us to draw a reason why the *right* is environ'd with such a weight of flesh since the *right* has a thin wall in comparison to it.



Tis moreover to be observ'd, that there is given for the same reason to the *portals* of the *heart* resisting this operation, unequal *fibers* (little ditches or pits they call them) arising in the folds of the breasts, and engrafted in the *portals*, that they may be as ropes or stayes which might hinder, if they in the contractions being stretch'd beyond their bounds, might be unprofitable for the retention of the blood; for the *left ventricle* they are more and longer.

The *arteries*, whilst these *portals* are open, being fill'd with blood abundantly rising in, swell unto great bignesse, and advance themselves unto a *Diastole*, and make a pulsation; and they again contracting themselves, the *portals* which are set against the mouthes of them are shut by the weight of the blood compress'd, and hinder it from returning to the *heart*.

By reason of the disposition of the *heart* is easie to perceive not onely by sight, but also by touch, this following order in motion, yea the very action it self, and the manner of performing of it in a living creature, especially in those of the greater sort, because the greatnesse of the *heart* falling and rising may be the better discern'd, and sooner when it is dying, because then motions are slower.

One may pretily observe and try by the grasp of the hand, that when the *heart* doth contract it self, with forced strength pressing on its *Basis*, at that time when it advances its point, and strikes the *br* with a pulse outwardly felt, it becomes lesse in quantity, and when the top of it is raised, besides that it feels more contracted and hard, its bignesse is impaired.

Let us give a reason for this: The actions of all parts are done by contracting, why should we deny this to the *heart*, which consists of contractible flesh, and of *muscles* as are most firm and strong, this flesh if it ought to fall and rise by swelling up and falling of the blood would be very unfit for the purpose, such a consistence is fittest for a strong and violent action, and a more flagging consistence fitter for passion.

If the *heart* seems to be uplifted by the foregoing contraction of the *ears*, which they discharge the blood, the *Stole* is not to be imputed to a dilatation: It most clearly appears from the being open'd every day, that the motion of the *ears* does precede, and did precede always.

In them there first appears a little disorder which beats, which being changed to the *right ear*, the *heart* is seen to grow; to which reason



...s, for the *ear* keeps the same number in  
...s pulses which the bladder had before, the  
...heart has a distinct and diverse motion  
...om it.

Because the motion of the *ears* is first,  
does not depend upon the motion of  
the *heart*, the *heart* is immediately uplifted  
by its action, not on the contrary, for  
they receive nothing immediately from  
the *heart*.

This is apparent, because when the  
heart beats no more, yea when it is dead,  
either of the *ears* do still beat in answer to  
their *ventricles*; after the *left ventricle*  
ceases off to beat the *ear* which is next  
it beats still, which being dead the *right*  
*ventricle* continues; which ceasing, the  
*left ear* supervives still; this abstaining  
from motion, at least from any that can  
be discern'd, there is a kind of trembling  
motion observ'd in the blood, rais'd as I  
think in the blood, being moveable, by the  
weak endeavour of the *ear*.

## C H A P. II.

*How many absurdities doe follow the  
nion of Cartesius concerning the ebullition of the blood.*

**L** Et us see what absurdities follow the doctrine of the ebullition of blood.

The most famous Man is forc'd to sign the *Diastole* of the heart and there *ries* at one and the self-same time; what if it be true, the *Portals* that are placed at the entries of them, are of no use, which is absurd to assert, since Nature makes nothing in vain.

It is known that the *arteries* have no *Diastole* and *Systole* but they begin and ends together through the whole body, which if they were extended through the *ventricles* of the heart, *portals* would be as unprofitable there as in the *arteries*.

To this adde, that there would then be no need of those *portals*, because there would then be nothing in the *arteries* to cause the return of the blood; they have not the force of contraction, as the most famous man himself affirms, nor is there in the body any cold which by constriction is repulsive, such as the most famous does not desire, but onely a lesser



that the blood may fall and make a *Systole*.

Secondly, it follows, that the three-pointed *portals* joyn'd to the *arteries* are shut by the blood, being coold and asswaged, which comes to passe at that time when the blood is not so able to shut them, or has need so to doe, namely when the *arteries* are not so full; and to speak in a word, when they have not power and occasion so to doe: for they are not shut by their proper force of contraction, nor by that of the *heart*, (which in his Letters to the Physicians of *Lovain* he denies) nor by the urgency of the *arterial* blood.

Besides, if the *Systole* of the *heart* be when the blood is refrigerated in the *arteries*; this either comes to passe because the blood in them being condens'd, there is place left for that which is coming out of the *heart*; or because the blood which is in the *ventricles* of the *heart* is coold together with it, that it may fall together.

If the first be true, the *Systole* of the *heart* will ensue upon that which is in the *arteries*, that is to say, its done at severall times; as if you would say, the blood is condens'd by cold which is in the *arteries*, and which is made lesse in the bulk, from whence the *portals* are open'd, and out of the *ventricles* there slides other blood, which can not be done all at one time. Thus it is prov'd, Because if the three-

pointed portals are presently shut after the *Diastole* of the heart, whilst the arteries are as yet asswag'd (if it did not cease they could not be shut, for the blood passing out, and being no lesse active than the blood which comes from without, would not suffer them to close) there would be both an aperture and a shutting of these portals in the *Systole* of the arteries.

If the last be true, Why is it not regenerated by the drops of the colder blood which enters afterwards? for that of the *veins* is cooler than that of the arteries, being more cold in the *lungs*, and yet ebullition is encreas'd by it; whence it follows, that in the very self-same object that which is lesse cold, performs greater actions than that which is more cold.

Lastly, if that which is liquified and rarified by heat, be likewise harden'd and condens'd by cold, the blood shall lose that thinnesse which it did acquire by the heat of the heart, by reason of cold; and if it be true, how can there be any difference betwixt the blood of the *veins* and that of the *arteries*? which is objected by Dr. Harvey p. 47. *Method*.

We do not receive the answer (Page 124. and in the following Epistle, *Quaest. I. verovic.*) which is return'd to the objection of the Physician of *Lovain*, (in the *Book*, Page 124.) in which, besides



the most famous man grants that the blood flowing out of the *arteries* into the *veins* through the remotest parts does suffer no mutation, he sayes, *That there are alwayes some drops in the Veins which did not flow from the Arteries, because indeed there is alwayes some moisture, which flowes into them out of the Intestines, and that all the Veins, together with the liver, are to be looked upon as one vessel; As likewise against his own position, (pag. 47. Method.) That the blood ought to retain the same qualities, which it acquires from the Heart, in all the Arteries; that the blood in the Liver is made red, and that is the reason it is found red in the Veins.*

From the *intestines* to the *veins* of the body there is no way but through the *porta* and the *liver*, which it self has but a branch from the *cava*, whose blood has not learn'd to swim against the stream, neither are the *portals* more open to it, thā returning from the habit of the body.

Besides, if the blood be thickned and incrassated the more the further it goes from the *heart*, how shall it enter the *capillar arteries*, yea those which are much lesse, or how shall it passe the *pores* of the body to nourish it? for the very least parts of the body are nourished and augmented according to all their dimensions, not by external apposition.

Like-

Likewise the motion of the blood would passe on very slowly if it were be performed by ebullition and refrigeration (swiftnesse, which is given by heat is taken away by cold) especially if it should passe forward drop after drop, albeit they are great (if the drops doe not outgo the bounds of drops.)

But why doe both the *ventricles* of the blood admit but one drop? nothing hinders but that it may be filled up to the top before it can boyl over; there is abundance of blood in readinesse, an ear pressing, an open way, and patent *portals*; besides that the great masse of the *heart* being augmented and diminish'd, and the elevation of the *arteries* through the whole body doe demonstrate that so much passes through.

The great *arterie* being opened all the blood flowes out; which cannot come drop by drop, although the drops were never so big.

Pray what becomes of the blood of the *heart*, which enters into the substance of the *coronal arteries*, does it likewise boiling up rise to a greater quantitie, and move backwards? or is it refrigerated in the flesh of the *heart* where the greatest heat should be? (because that from thence the *ventricles* are hot, and then that from which every thing is of such a nature,

much



must needs be more of that nature it self ) it is not to be believ'd : *veins* which are answerable to *arteries* in bignesse , doe receive no other than which returns from other flesh.

To this add , that the *aorta* being stop'd in a living creature by a *ligature* , the ebullition would be seen with our eyes, nor would it give over so soon , especially the *heart* still beating.

If taking the *heart* out of the body , without any regard to the order of the *ventricles* , you cut it in length, or crosse, or as you please, into many pieces, reserving none of the *ventricles*, (which ought to be shut before the sides be raised, otherwise the force of your ebullition would passe into air ) every piece of it leaps a while , yea by erecting and contracting it self it endeavours to shake off the trouble of the surrounding air , and after every leap ( in which it is easie to see that the pieces are made lesse , especially if you look upon the greater pieces ) flaggs, and falls , leaves working , and after a short resting , it returns first to a short , then to a longer erection ; in the mean time if you prick it with a needle , or any other ways molest it , it raises it self with several and new leapings , that it may oppose it self to outward injury , without any sign of heat, ebullition , or dilation.

Like

Likewise in the body the *heart* being whole utes to hinder the trouble of the blood distending it by its contraction, and after every action desist from working, and rest, in which time it is again fill'd and overwhelmed by new blood from the *ear*, and then has it new occasion of contracting it self.

Heat the author of evulsion and dilatation (of which it appears there followes a much contrarie effect) cannot be called the cause of this contraction. I believe that the body being enlivened is driven to contraction by the Soul, the moderator of it, which is the efficient cause of all actions, according to the opinion receiv'd every where, and by all persons.

No actions of the body being disposed are performed but when the parts do keep off those things which are uncouth and hurtfull; one part moves and extends another part by contraction; in contraction and vicissitude of rest life consists, which being begun with contraction, is ended in rest.

The most famous man disputing in his question propounded to the Phisician of *Lovain*, concerning the cause of the motion of the *heart* when it is taken out, does not draw me from this opinion; *Epist. Quest. Beverov. pag. 127. How shall that motion depend upon the Soul of a man, which*



is likewise found in the parts of the Heart being divided, since it is our belief, that the reasonable soul is indivisible, and has none other, either sensitive or vegetant, joyn'd to it? He seems not to derogate from the motion of the Souls of other creatures by this question, he only moves his difficulty concerning mans soul, which troubles me so much the lesse, for this being comprehended under no dimension, and being incorporeal, seeing it is not circumscrib'd by its own body, can neither suffer any division nor circumscription, nor shall it suffer any untill that at the last day it arise bounded by its own body to judgement.

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## C H A P. III.

*Of the heat of the blood; the definition of heat; the qualities of the Elements remain in a mix'd body; one heat in all, differing only by degrees; how heat may be taken out of the blood.*

**B**Y this I believe it is prov'd abundantly, that there are no spirits wrought in the heart; and that the blood suffers no change in it, much lesse gains any perfection there; and lastly, that there is no  
more

more heat in the *heart*, than in any of the rest of the *intrals*. Let that which is said concerning its principality and government in which it excels, be decided by indifferent judges.

One thing as yet remains to be resolv'd, and that is from whence the blood acquires its heat, and from whence lively and refreshing heat comes to the parts, if it have it not from the *heart*; for it is most certain, that heat, together with the blood is carryed over all the body, and thence from thence the heat of the parts are increas'd, and that thence they are fomented, and the more blood we have the hotter we are.

Heat being a tactile quality, and the form of the hot subject, is an effect of the element of fire; it is by the Philosophers defin'd to be an active quality, gathering *Homogenealls*, and dilgregating *Heterogenealls*; these things are perform'd by motion, by motion the bond of things mixed is dissolved, and every thing that has any tie upon it moves to its own beginnings, when fire does stir and disjoyns things mix'd moving of their parts by its active forces (they consisting of the union of contraries) every thing tending to its own, particles of fire are easily joyn'd where there is a greater conflux of them, whence fire receiving strength stirrs up  
green



greater motion of the little combustible parts.

This, perchance, gave occasion to the most learned man *H. Regius*, that in his *Phys. disp. I. Thes. 17. & Physic. fund. pag. 8.* he calls heat a various agitation, or motion of insensible parts.

It seems to me to be no motion nor agitation, but something which is produc'd by motion out of the subject forementioned; from whence the reason is easily taken, why the stronger and the swifter the motion is, heat is the more easily excited in creatures: for the more and sooner that heterogeneousals are separated, fire particles meeting in the fabrick of all things, being join'd with greater convenience, doe improve their force, and cause heat, which is augmented, when by dissolving the bond of other things, it adjoyns to it self other fire particles flowing from the same matter.

For all things consist of four Elements, of which every one concurring with their whole strength when that which is mix'd constituted, keep their qualities entire, and upon occasion do endeavour to show them, and do naturally show them as much as they can, without dissolution of the creature: and although they are forc'd to subject them to a more powerful form, yet they do not perish, nor  
is

is the one chang'd into another.

*Nullius exitium patitur natura  
deri.*

Nature destruction of all things  
hors.

Particles of fire are so much dulled  
the concurrency of other Elements,  
being as it were asleep, they can show  
force, and doe not so much as move  
sense, yea seem quite extinct, which  
withstanding by motion and contrition  
some other cause assisting, being united  
not onely heat, but burn also and raise  
fire, especially in the dissolution of  
thing.

In a body that is too strongly mix'd  
that it cannot be dissolv'd, they by  
help of extrinsecal fire are sometimes  
much intended and mov'd into act  
that they far surpass the other Elements  
ry parts of the mix'd body, which not  
standing, the external agent being  
mov'd, do presently return to their naturall  
constitution.

Although the actions of fire, according  
to the excesse of its degree, perform  
actions, both in things animate and  
inanimate, yet there is one and the self  
heat in all, that is to say, the Element  
nor besides this is there any other  
found, whether it be call'd constitutive  
sustentative, or killing, or whether



call'd; of celestial temperature, or natural, innate, implanted, influent, or preternatural, feaverish, universal, particular, or by what name soever it is design'd, it is only distinguishable by its measure, and exuberance of degrees, not according to its form.

Nor does that differ, which by outward touch is perceiv'd in a living creature, from that, which flowes to the constitution of any part, whose form continues likewise a while after death, although all perceptible heat be gone before, and the whole corps feel cold, till that its fabrick be dissolv'd by putrefaction, and every particle return to its beginnings; in which motion the particles of fire being conjoyn'd, do make heat perceptible to the touch, especially if they be kept from wind; for that coming freely to them they should be blown into the air, before they could be united and make up a sensible heat.

If it come to passe in a living body that something in any part of it being shut up, does putrifie it, swelling at last and making an eruption, and mix'd with the rest the humor increases the heat; for by sharpnesse or other troublesome qualities irritating the parts, and moving them to faster propulsion, it begets a swifter motion in the blood, whence greater heat is engendred: just as if heating meat or  
P drink

drink warm'd were receiv'd for nourishment, which had many particles of fire in it.

As heat is excited and produced without the body of the creature, to wit, when it is freed from its bonds, so it is likewise gotten in the same motion, and is conducted out of the nutriment: This (the parts vivified and moved by the soul) is agitated, stirr'd, and divided very small in which action the fiery atoms (if I may be allowed so to speak) being united and convening in a swift and indefinable motion, make their strength to appear manifest heat.

#### C H A P. IV.

*What things are required to the heating the blood; from whence blood becomes moveable; how nutrition is caused; to be divided into the smallest parts.*

**T**Here is requir'd in this action or production of heat in the living creature, first, mobility of the blood, then something moving it, and lastly a disposition of the ways, through which and to which to bounds, it may be moved and contained.



It has its mobility partly from the whey-  
ish humor, but most from the air, which is  
added to the blood in the *lungs*, by the me-  
diation of this, it being divisible into  
infinite parts, can passe through all, even  
the most thickest parts.

There is so great affinity betwixt divisi-  
bility and mobility, that the more easie a  
thing is ordained to be divided, or into  
lesse parts, it is so much the more mova-  
ble. Mobility is extremely necessary to  
the blood for distributing of nourish-  
ment.

For nutrition is the union and assimila-  
tion of the nutritive humor to every part;  
which nutriment, that it may become one  
living thing, together with that which is to  
be nourished, is not perform'd by external  
opposition, but it ought so to passe the  
least particles of the members, that accor-  
ding to all their dimensions it may be ad-  
ded and united to them.

It is likewise to be observ'd, that all  
that is brought thither is not united, see-  
ing the very self same blood has divers  
parts in it, of which some are most fit and  
not for this part, and other some for  
another part, yet none doe stick to them  
being appos'd, but those that have a re-  
semblance with them, the rest being un-  
going farther return to the *veins*; if  
there be a greater quantity added than is

exhausted, there is made an accretion, but if a part that did adhere before be carryed away with it, there happens a decretion and extenuation of the parts.

The very way of its preparation shews the mobility of the blood, for no part the *Chylus* is admitted into the *vasa lactea* but the thinner and most movable part of the *Chylus*, which after it has first pass'd through the glandules of the *mesenterie*, and the *pancreas*, and is wash'd with strain'd blood and mix'd with a little *choler*, it runs through the great substance of the thinner of the *liver*; and at last being imbued with air in the *lungs*, it gains its requisite perfection.

But the nutrition and augmentation which is perform'd in every part, shews how moveable and divisible the blood is prepar'd is.

And experience likewise is witness that much this division contributes to the action of heat; for we see, that bruised and powder'd medicaments doe act swiftly and more powerfully than those that are whole.

We will instance that place of *Celsus* who *Lib. de med. simp. facult. cap. 11* thus; Of those which are confess'd to be hot, none at all doe heat us, before they be beat and ground very small; whole pepper applied to the body shewes no heat; if like meat



*strew'd upon the tongue or skin, it overheats, especially if it be rub'd.*

C H A P. V.

*Why the blood ought to be mov'd; the Heart the chief moving Instrument; from whence the abundance of the blood transient may be collected; the Arteries assist the Heart; their actuating power is proved; what the particular parts do confer to motion.*

**T**His mobility of the blood is not sufficient alone to the production of heat, for unlesse it be driven by some impulsive, and be stirr'd with a swift motion, it should never become hot; for fire particles, unlesse they be joyn'd, do not heat, they are drawn out with swift motion, for since they excell in swiftnesse beyond the rest, they leap out before the rest, and being deliver'd from their bonds, do meet, that they may exercise their power.

Albeit the blood be dispos'd to motion, yet because it is destitute of life (as well as the spirits, if there be any in the body) it is no wayes able to move it self; for all Motion proceeds from the Soul, nor can any thing but that which has a Soul move

it self, or be sensible, it only vivifies the body and its parts, which being orderly fitted, it empowers them with its faculties.

This moving and impulsive Soul does chiefly make use of the *heart*, which having large and contractible flesh, thrusts out the blood receiv'd from the *veins* into the *arteries*, without any other intention but to ease it self of that heavy burthen with such frequent and swift pulsations that from them, and likewise by comparing the contractions & dilatations of the *heart*, and the greatnesse of the flow of the *gates*, and the elevation sensible to the touch of all the *arteries*, through the whole body, one may by conjecture easily gather how swiftly by a continual motion the blood passes through all the parts.

The *arteries* and all the parts do con- cond the *heart* in this motion; they be fill'd and swell'd by the force of the action of the *heart*, when they are contracted and oppress'd by the weight of the neighbouring parts doe dispense it according as occasion is to all the parts; the *Pneumonick* into the *lungs*, the *arteries* into the whole body, making no distinction of heaviness of lightness; for the lighter does not goe upwards, and the heavier downwards, but with one force without any distinction it is moved to



parts most empty or least resistant.

Let no man think because it was said before, that the blood did leap out by the impulsive action of the *heart*, in the *Diastole* of a wounded *arterie*, that therefore the blood has all its propulsive force from the *heart*, and that the *arteries* contribute nothing to it, because it seems to leap out when they are filled.

It will not from thence be concluded, that the blood in the *Systole* of the *arteries* does not move further; for they do fall and are contracted, that they may again rise in their *Diastole*, and though at that time the blood do not flow out of them with so great force as to leap, yet it slides out of them as out of a *vein*, and as much as the closing lips will suffer to flow forth.

It appears how much power the *arteries* have in protrusion of blood, by the ligature, for no sooner by it, nay even the great *arterie* is tyed, but immediately beyond the ligature it is emptied in the space of three or four pulsations, although by hinderance of the band there proceed no impulsive force from the *heart*.

All the parts which are to be nourished by the action of the aforesaid *arteries*, are imbued with blood and nourishment, that they are distended and swell, and do naturally endeavour to thrust out all

which is strange and hurtfull to them; for besides that they are so fram'd, as by their reluctancy and their own weight to remove the humour which they have receiv'd, and do contain within them, because the blood contains many different parts, which cannot be turned and assimilated into any living thing, they are the more willing to this, because without cease or intermission new may succeed the former. The abundance of blood shewes the truth of this return of blood out of the habit of the body into the *veins*.

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## C H A P. VI.

*The way destined to the motion of the blood; how it is disposed; wherefore there are Portals for the Arteries, and not for the Veins; and wherefore there are some in the Heart. How far the passages of vessels may be extended; What is understood by the habit of the body; manifest Anastomoses are not necessary to the motion of the blood; The opinion of Galen, and of Harvey concerning*

**T**He parts which make up the way through which the blood may



and in which as in bounds it may be contained, and its heat preserved, are the *heart*, the *arteries*, the *pores* of the whole masse and the *veins* with their appendixes.

The *vena cava* with its *ear*, the *right ventricle* of the *heart*, and the *Pneumonical arterie* make up one passage together, as the *vein* of the *lungs* and the *ear* fastned to it, and the *left ventricle* of the *heart*, and the *arteria aorta* make up another. Either of these is joynt and undivided, apparent to the view, only in most places it is closed with *valvs* hindering the regresse of the *blood*.

There are a great many of these, which are connate in the concavities of the *veins*, both, because there is an inequality in the motions of the body, as likewise because by outward compression they doe easily yeeld, by reason of the softnesse of their *tunicles*, whence not only the motion of the blood might be hindred, but it to the great endammagement of the body might be pressed backward, unlesse that were prevented by nature with *valvs*.

These are fram'd at the entry and egress of the *heart* only for the first reason, to wit, because the motion of the *ears*, *heart*, and *arteries*, is not the same but diverse: there are none granted to *arteries*, because at one push they are elevated by the action of the *heart*, and  
when

when that ceases they are likewise contracted and fall; next, because for the hardness of their substance they are not so easily squeezd together by the weight of the parts adjoyning.

In these passages the blood gains nothing from the *heart* or *arteries*, but more swift motion, all that it has is added to it by the *veins*; not that they give anything of their own, but all, which is contained in their passage or capacity, disflow from the substance of the parts.

The beginning of these describ'd passages begin together with the *veins*, and like marks or bounds end together with the *arteries*, which both parts are similarie, called, because they have a similitude one to another, and any part of them call'd by a like name, a *vein* or an *artery*.

Therefore wheresoever they are so ingrafted into the substance of the parts and are so entangled with many divisions and divarications, that they do quite lose both name and similitude, they are taken for substance which flowes thitherto for the nutrition of the parts.

There the passages begin with the *veins* and end with the *arteries*, and lose their name, and as that which is within them is called blood, so whatsoever is found beyond the forenamed bounds is called the habit and substance of the body which



which being pervious every where with pores, gives passage to the blood through its most hidden recesses, it being first subtilized and made moveable by the lungs, that the very least portion of any particle might be nourished according to all its dimensions.

I doe not hold it necessary to set down the Anastomoses of the *arteries* and *veins* manifest to view, seeing it being exquisitely divided can passe through the very substance of the body, swifter indeed through the fleshie part than through that which is more solid, yet with such a harmony of action, that one does not hinder the others action, or forbid it (so long as the body is in health)

The most famous man *De Cartes* makes these Anastomoses so necessary, that by them he thinks the way is only open to the circulation of the blood, yea so manifest and patent will he have them to be, that that which out of the *arteries* through their extremities does flow into the *veins*, suffers as he says no change, and if there be any difference of the *venal* or *arterial* blood, he says it gains this by reason that something flow'd thither from the *intestines* and the *liver* (which we have refuted in a few words.)

He says, that the commendation of this Invention is to be ascrib'd to an *English* Physi-

Physician, which broke that Ice; to we resolv'd that doubt, why the *veins* are not empty'd, and the *arteries* not burst, first all the blood which passes the *heart* flows out of these into them.

It is true indeed, that venerable Doctor *Harvey* endeavouring to render his Theory of the Circulation of the Blood more possible and plain to the minds of those that were averie from it, (because soon as he says. beleeve nothing, but what they have an authority for) brings that place of *Galen* (*de usu part. 6. cap 10.*) where he says, *That there is a mutual Anastomosis of all, and an interchangeable opening twixt the veins and arteries, where they touch.*

But the venerable man cites that place only as it may further his purpose, though it be his intention that the blood pass through the habit of the body; and without reason, since nutrition is performed in manner aforesaid.

Besides, it is manifest, that if any place where no *vein* is to be seen, be wounded, the blood sweats out from thence, or flows out: bones being broken, which are driest and most solid parts of the body, shew flesh, which is a sign of blood, at the sides of the breaches, (which we have often seen growing upon movable fractures) by which they grow together, and are



interchangeably knit, this flesh too in time growing to be bone, and acquiring hardnesse,

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## C H A P. VII.

*It is proved that heat is stirred up by motion, as well in living creatures as in things inanimate; Of the place where heat is ingendred; The conclusion.*

IT is therefore certain, that the blood is very movable, and infinitely divisible into very little parts; and likewise that the heart does stir it, and powerfully drive it, as likewise the arteries and all the rest of the parts, by a continued, strong, and most swift motion, first, through open and clear passages, then through the substance of the body pervious by pores, and not hindering the passages of it whilst all parts are sound.

Its manifest that heat is stirr'd by motion; we see, that those things which are rubb'd doe grow hot, and that flints knocked one against another to send out sparks; sticks too being mightily mov'd and stirr'd take fire; when notwithstanding they are cold, as well as growing trees, metals, and all inanimate things, because they are immovable.

Like-

Likewise lesser and more imperfect creatures, although they live, yet by reason of the slenderesse of their motion, are not only not hot, but are cold to the touch notwithstanding that abundance of fine particles have been in their composition which *Palmer-Worms* and *Cantharides* by their example demonstrate, if they are taken inwardly, or outwardly apply'd to mans body, they doe burn and exulcerate.

If the body be stirr'd with running, with any other Exercise, whence the blood may be rais'd with a swifter motion, the body grows hot from thence; which likewise comes to passe, when the parts of the body being irritated either with sharp or spic'd meats, or strong drink, or any other cause either wholesome or obnoxious, doe stir the blood swifter than ordinary.

According to the authority of *Galen*, *Morb. causis lib.* All bodies use to be over-heated with finifter motion, or putrefaction, by the neighbourhood of some hotter body, or by a striction, or by hot nourishment.

If any do desire to recite the proximate causes, they are they which joyn fire particles together, or doe bring them into action; there is furnish'd fit matter by which they may have ment for them to work upon, from which



they are drawn by motion; by the neighbourhood of hot things they are help'd to perform their strengths, the form of the mixt or part thereof remaining; It is forewarned that eventilation might be hinder'd, lest that they be blown into the air or dissipated.

Its certain then, that by motion heat is drawn out of things, but where, or in what place of a creature does that come to pass, whether or no in the *ventricles* of the heart? seeing that it is mov'd without all intermission, and is the first and chief organ serving for the motion of the blood; and again, because all the blood flows to them.

The heart is indeed the first in order, but not the chief organ in the motion of the blood, and that it performeth the office of a Steward, by whose power after it is perfected, it is distributed into the whole body for the nourishment of the parts. But because the masse of blood staves there compact and entire, the composition of which,inders and abhors the increase of heat as much as it can, that cannot be ascrib'd to the *ventricles* of the heart, that they increase heat in the blood, or that in them is heat drawn from it.

I doe beleieve, that wheresoever nutrition is performd, there this function is most manifestly executed, and that the parts  
whilst

whilst they are nourished, are heated, then the composition of the blood is dissolved and is divided very small; then also the fire particles freed from their fetters, & being united, do shew their force by heating.

But if it be perform'd according as the temperature does require, and as may be endur'd by the composition and union of parts, a gentle and natural heat is thereby excited, and all the actions of the body are perform'd according to nature, as in a sound man is requir'd.

But if the blood being peccant either in quantity or quality, as well by reason of internal as external qualities, or by reason of immoderate exercise, or greater passion of the mind, and by such things as may cause a swifter motion in the blood beyond measure; then the actions of the body are disturb'd, feavers are caus'd, and symptoms rais'd in any part, according to the disposition of the temperature and passages: a rehearsal of which, since it exceeds our limits, it is better to have shown that the *heart* in the body of an animal has no pre-eminence or principality, nor is the store-house of the *spirits*, nor the fountain of the blood, because it has no superexcellent heat above the rest of the noble parts.



## An Addition.

Whether Harvey thought that the Ventricles of the heart were so expanded in the Systole that they might receive Blood, and so shut up again in the Diastole that they might thrust it forth; That such a sequel did follow from the supposition of Cartesius; which Opinion of theirs is the best concerning the Systole and the Diastole.



See no reason why the most famous R. de Cartes should say, That the venerable Dr. Harvey did think that the ventricles of the heart were dilated in its Systole, that they might receive blood, and were streightned in the Diastole, that they might thrust it out into the arteries. Let us consider this business rightly.

The most famous man thinks that the heart, by reason of the ebullition of blood, rais'd by its implanted heat, does swell, and rises into Diastole at that time when the breast is struck, and the pulse may be felt outwardly.

Q

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Venerable Dr. *Harvey* says, that the *heart* at the same time that it strikes the *breast*, it stretches all the *fibers*, up-lifts itself, is on all sides contracted, is unfill'd and empty'd, and is in its *Systole*.

The same time in which one says there is a *Systole*, another says there is a *Diastole*.

Is it therefore fit for *de Cartes* to ascribe that to *Harvey* which is against his mind? as if he had said, that the *heart* was dilated, and did receive blood in the *Diastole*, because *de Cartes* is of opinion that the *Systole* is at that time, though he does indeed affirm and demonstrate, that the *Diastole* is then made. *Harvey* by the same right might say the like of *de Cartes*, but let us see who must bear the blame of this.

The venerable Doctor *Harvey*, an exquisite searcher of living creatures bodies observ'd two times in the motion of the *heart*; to wit, one time of motion when the *heart* moves it self, and is in action; another time of its rest, in which, ceasing from action, its mov'd and extended parts receive the immision of blood from the *ears*.

He says, that these times may be manifestly distinguished, and accurately observ'd in colder creatures, yet best in hottest creatures, when the *heart* begins to die, and beat more slowly and faintly.



For then the stops of the times are longer, which in a veget or lively *heart* can hardly be discern'd; then likewise the *heart* is seen, after the performance of its *Systole*, to be at rest, and to be (to wit in the creature departing) loose, flagging, and weakened, and lie as it were drooping.

He says, that the *ears* at this time do stretch and contract themselves, and by impulsion drive the blood into the *ventricles*, in the distention of which they make a *Dia stole*; which being done, that is to say, when it is extremely distended, begins (sayes he) the motion of the *heart*, at which time contracting it self every way, and leaning upon its *Basis*, it is erected, and being lesser in quantity and oblong, it lifts up its point and strikes the breast.

He calls this time the *Systole*, the former the *Dia stole*; The first begins when the *heart* is emptied, and rests from its work, and leaves, when the *heart* is full; The latter does begin when the *heart* stretches all the *fibers*, and contracts them, and ends when that work is perform'd.

Let any indifferent man judge, if venerable *Harvey* be of opinion that the blood in the *Systole* is receiv'd into the dilated *ventricles* of the *heart*, and thrust out into the *arteries* in the *Dia stole*, when they are streightned, especially since the matter

being yet in controverſie, it is not determined whoſe opinion is the beſt.

Let us canvaſe the moſt famous mans opinion of the *Syſtole* and *Diſtole*, and whether or no that will follow from his own writings clearly, which he carps at others.

Seeing the *Diſtole* and *Syſtole* have their times in which they are meaſur'd, and are mutually diſtinguiſh'd one from another, let us ſee how the beginning of one and the end of the other, can be diſcern'd from his ſuppoſition.

We know the difference of the *Syſtole* and *Diſtole* by our touch onely, by the great help of ſkill ( which is moſt uſual in the pulse of the *arteries* ) or meerly by reaſon.

The firſt way is, becauſe the extent of the *heart*, as likewiſe of the *ears* and *arteries*, is a *Diſtole*, and a *Syſtole* the contraction of it: That time which is next to the higheſt extenſion is of the *Diſtole*, as likewiſe that is ſaid to be of the *Syſtole* which is next to the higheſt contraction. *Diſtole* begins in the middle way toward dilatation, and in the middle way toward contraction it ends, the reſt of the time is aſcribed to a *Syſtole*.

The other way which is by the helpe of reaſon, is judg'd to begin ( if it be true ) according to the moſt famous mans opinion



on) when the ebullition begins, when the heart begins to swell with blood, and the *Systole*, when in the refrigeration of the blood it falls again.

Let it be taken how you will, it follows of necessity, that the blood in the *Systole* is admitted into the *ventricles* of the heart, and that it is sent abroad in its dilatation or *Diastole* into the *arteries*.

In the first there is no doubt, it remains that we demonstrate it according to the last way, seeing he himself does not aver it openly.

But he says, pag. 44. and in his following book of *Method*, *So soon as two drops of blood are enter'd, that is to say, into either of the concavities, which are presently dilated and rarified by reason of heat which they find there; for which cause they make all the heart to swell, and doe withall thrust and close the five portals that are in the entry, from whence they flow.*

The most famous man seems to affirm, that the blood is enter'd before the ebullition begins; for, says he, after the drops are enter'd the blood is rarified, which makes a *Diastole*, whence it is apparent they came in in the *Systole*.

Consequence likewise teaches us, That the blood enters into the *ventricles* when the *portals* plac'd at the heads of the *veins* are open, but it goes out when they are

shut, and those of the *arteries* are open. But the most famous man opens the *porrals* of the *veins* in the *Systole*, and shuts them in the *Diaſtole*, therefore the blood does enter into the *ventricles* of the heart in the *Systole*, and not in the *Diaſtole*.

Besides he imagines, that the *arteries* come to be in their *Diaſtole*, by reason that the blood entering is dilated, and that they have their *Systole* when it is refrigerated; wherefore in the *arteries*, out of which the causes of the *Systole* are derived, the times of its entry and condensation will be more distinct than in the heart, from which the cause is taken of its *Diaſtole* entry, and dilatation.

But what need we many demonstrations? The most learned *H. Regius*, Professor of Physick in the University of *Utrecht*, and a notable follower of *de Cartes* his Philosophie, *Fund. Physicor.* lib. page 183. in expresse words says, That the *Diaſtole* is a part of the pulse, in which the heart, by the rarified blood coming out of the *Vena Cava* into the right Ventricle, and out of the *Arteria Venosa* into the left in the *Systole*, according to its depth and breadth dilated, and swells.

And a little after. Nor is this part of the pulse to be accounted the *systole* of the heart from thence, because cutting away the point of the heart in a living creature, the ventricle



cles of it are felt in this case, and seem to be streightned; for the *Dia stole* of the heart is not to be reckoned from the dilatation of the ventricles, but from the swelling of the heart it self, which may come to passe when the ventricles are streightned.

Tis therefore to be concluded, That the most famous man does determine, that (for they cannot receive blood but they must be dilated, especially by drops, which he says are big enough, because the wayes are very wide by which it comes, and the vessels from whence very full of blood, by which they swell in the emptying of the ears) which he carps at in venerable D. *Harvey*, that the *ventricles* are dilated in the *Systole*; that they may receive blood, and are streightned in the *Dia stole*, when the blood is thrust out into the *arteries*.

May not Dr. *Will. Harvey* with good reason say, that the most famous *R. de Cartes* his opinion concernig the motion of the heart, is destroy'd by his own proper experiment, in which he strives to confute and strangle the opinion of famous *Harvey*? Because we are come so far to to know the different opinions of these most famous men, it will not be amisse in comparing of their Arguments, to see which of their opinions concerning the *Systole* is more plausible.

It being received through all ages, that

the *Diaſtole* of the *heart* was then performed, when by extension, like a pair of bellows, and drawing blood into the *ventricles*, it was ſaid to be fill'd, and that that came to paſſe at ſuch time when it ſtruck the *breſt*, and the pulſation was felt outwardly: The venerable Doctor *Harvey* did obſerve, that at that time there was not a *Diaſtole* but a *Syſtole* perform'd, nor was the *heart* dilated; or received blood, (when the *heart* being at reſt, and deſiſting from its labor, was extended into a greater quantity, the blood being thrown in to the *ventricles* by the *Syſtole* of the *ears*;) the *Syſtole* being an action of the *heart* by which it thruſts out that blood which it receives into the *ventricles*, abroad into the *arteries*, and raiſes them into a *Diaſtole*.

It is to be taken notice of, ſayes he, that the *heart* when it moves it ſelf is contracted and ſtretch'd (like other parts which are contracted in action likewise) whence it comes to be of leſs compaſſe, which is both apparent to the ſight and touch, becauſe it is minorated, and is perceiv'd to be harder, and more reſiſtent.

He proves this conſequence by the example of the *muscles*, which when they contract themſelves become harder and more reſiſting; beſides the *fibers* being contracted, are ſhortned and thickned, and



To the substance and wals of the *heart* are thickned at that time.

He proves that the *ventricles* are not fill'd with blood at that time, because they become more narrow, and are more constricted, and are lesse capacious, as likewise they are seen to be emptyed; for upon the inflicting of a wound, the blood comes out leaping, which is thrust out by the contraction of the *heart*. Lastly, the *heart* becomes whiter, which when it is fill'd is flush'd with a red colour, which is almost apparent in Fishes and colder creatures,

All the parts when they are in action are evigorated, but resting are flagging and soft; in the time of the Pulsation, the *heart*, because it is in action, is evigorated, contracted, and it erects it self so much, that it strikes the breast.

These are the reasons taken out of the motion of the *heart* and blood of Doctor Harvey, by which induc'd, he endeavours shew, that there are two times of the motion of the *heart*, one of the motion in which contracting it self it strikes the breast, in which the *Systole* is perfected; another of its rest, in which the *Diastole* is done, and the *heart* is filld with blood and attended.

The most famous *de Cartes* attributing action proper to the *heart*, but affirming

ming that its motion is excited by no following power or faculty of the soul, artificially by the heat which is imparted in it, which dilates the blood, stirs up its ebullition, thinks that heart is uplifted and strikes the brest, proved especially by these reasons, as they are set down in his answer to the Physiarn Lovain:

*In a live Cony, after the top was cut the Basis of its heart remaining still fast to its vessels, did beat long enough, and in saw very conveniently those concavities are called the ventricles of the heart too come larger in the Diastole, and narrower in the Systole.*

And a little while after: You must notice, that to perform this experiment right, you must not only cut away the point, but half the heart or more, and you must essay this in a Conie, which is a fearfull creature, and not in a dog.

For in dogs the ventricles have several involutions, the concavities of every one which are so extended by the dilatation of the blood, that in the mean time the general concavities of either of the ventricles is streightned. Lastly, And then that man the touch be prov'd to be dilated, for when taken hold of with the hand it feels a deal harder in the Diastole than in the Systole.



To these the most learned Doctor Regi-  
us, fund. Physic. pag. 183, addes: If at  
that time the heart and the arteries be  
wounded, from the swelling heart, and the  
dilated arteries the blood is seen to leap  
out.

Besides in the following page: At what  
time the impulse of the arterie is felt to  
cease, at that time we see that side of the  
heart which looks towards the sternum to  
fall, and there especially where it answers to  
the orifice of the aorta; and the right side, and  
the left, towards the right and left ribs  
flaps, the point recedes from the Basis, and  
the whole heart, witness your own sense, be-  
comes loose, flagging, and soft, but woun-  
ding the heart and the arteries at that time,  
no blood comes out of them, and their wounds  
close.

These are the demonstrations on both  
sides, almost the same, but to divers pur-  
poses, by worthy men; what shall we in  
this case conclude?

If then these reasons be according to the  
first way, but briefly consider'd (as was  
said how the *Diastole* and *Systole* some-  
times might be distinguished,) (that is to  
say, if the *Diastole* be said to be when the  
heart is exceedingly swell'd, and the *Sy-*  
*stole* when it is lesse swell'd) the Argu-  
ments of the famous *de Cartes*, and most  
learned *Regius*, will seem to inferre some-  
thing.

But

But if you consult with reason, you shall find that the *Systole* begins in the height of the *Diastole*, to wit, when the *heart* extremely extended by the blood stretching or contracting the *fibers*, thrusts it out into the *arteries*; but it desists from this action, when not being able to contract the *fibers* any more, it loosens the giving occasion to a new *Diastole*, which begins when the *heart* leaves action, and is done whilst the *heart* is quiet, and till begin a new contraction.

The *Diastole* and *Systole* being thus considered, a blind man may see that the opinion of the venerable Doctor *Harvey* is establish'd with most firm reasons, that it must be concluded that whilst *Diastole* is perform'd, that the *heart* rests, that the *ventricles* are fill'd and come larger, that the walls are extended and grow thin; and that it self is augmented in bignesse according to all its dimensions; and that in the *Systole* it moves it self by its own proper action, invigorated, by contraction the walls are incrassated, it self minorated, it advances its point, the *ventricles* are strengthened, and by squeezing are emptied, blood is thrust out into the *arteries*, they in the mean time advance themselves into a *Diastole*, at that time when the *ears* are erected.



These things will be more manifest, if in a lively body you consider, that the sides of the *heart* doe not fall, nor that it falls flapping, loose and soft towards the right or left sides, but that this happens onely in dying creatures; examples of which venerable *Harvey* alleges, that the time of the proper motion of the *heart*, and its rest might be more evidently distinguish'd, and that he might the more evidently demonstrate whilst all the actions are slow, that the *heart* does move and contract it self in the *Systole*; and rest from action in the *Diastole*.

By a sound Animal these things are so quickly performd, that scarce has the *heart* done its contraction, but it is streight fill'd again by the urgency of the blood through those open wayes, and contraction of the *ears*, in the twinkling of an ey, and sometimes sooner, so that it is a hard thing to discern the filling and emptying, if not impossible.

True it is, that at the same time blood leaps out of the wounds of the *heart* and *arterie*, in the *Systole* of this, and *Diastrale* of that, by the urgency or contraction of the *heart*; for this being empty, whilst it is fill'd and uplifted by the *ear* into a greater quantity, although the blood come out in the mean time, yet it comes not out

out with leaping, for the action of the *heart* is not strong enough; then the *ventricles* which are empty, and must be fill'd again, hinder the leaping of it; but the more forcible contractive strength of the *heart* makes the blood leap out through *wounds*, out of its own wound in squeezing out the blood, out of the wound in the *arterie*, when it extends it by impulsion.

Let us likewise adjoyn our arguments by which we think Dr. *Harveys* opinion may be confirm'd.

If the blood were rarified, and acquiring greater bulk in the *right ventricle* (let the same be said of the *aorta*) Nature ought to have given a greater orifice to the *pneumonical arterie*, which might be wide enough for the passage of the blood; the very quantity which enter'd in the *Ductus Stole*, ought to come out in the following *Systole*, the bulk of which, if it be augmented, it should need a greater outlet, according to the augmentation of the blood, no less than we see the hole of the *vena cava* by which it is joyn'd to the *heart* answers to the bignesse of the part which is above the *heart*, and likewise to which is below the *heart*.

Moreover it is certain, that according to *de Cartes* his own confession the *ears* have a contrary motion to the *heart*, and do

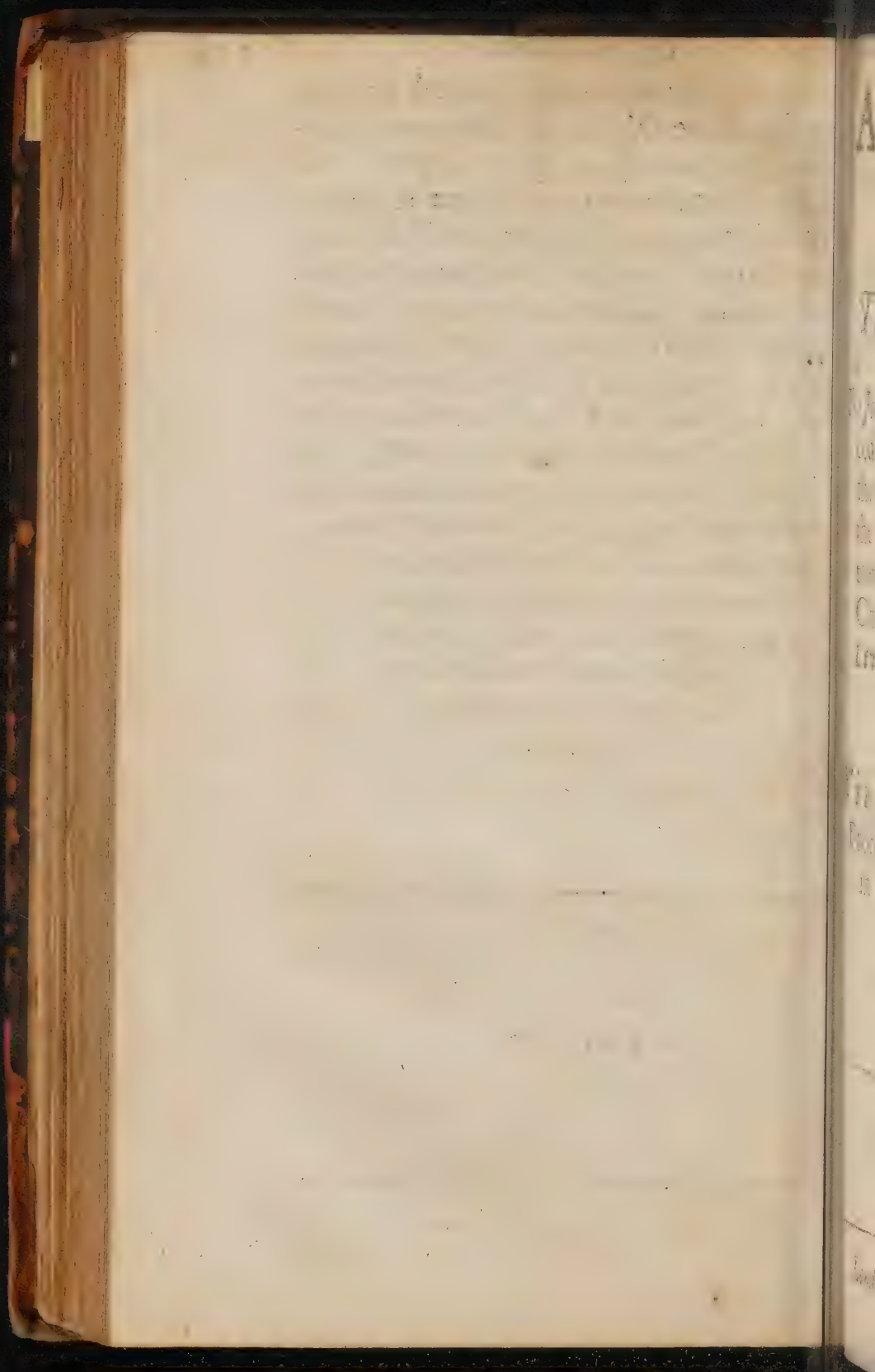


lag when it is raised, and indeed at that time when the *Diaſtole* of the heart is according to *Harvey*, they are emptied and all, but when by its contraction it ſtrikes the breaſt, they are fill'd and ſwell'd. From theſe things it manifeſtly appears, that it is to be concluded, that at that time when it ſtrikes the breaſt it moves it ſelf by contraction, it thruſts out the blood into the *arteries*, and is in its *Syſtole*, but when it deſiſts from this action, and is at reſt, it is fill'd with blood and extended, the cavities are made larger, the ſides made thinner, that all of it in its bulk, and according to all its dimenſions, is augmented, and is in its *Diaſtole*, far otherwiſe than the moſt famous man thinks.

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*F I N I S.*

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T W O

# ANATOMICAL EXERCITATIONS

Concerning

## *The Circulation of the Blood,*

To *John Riola* the Son, the most experienced Physician in the Universitie of *Paris*, the Prince of Dissectors of Bodies, and the Kings Professor and Dean of Anatomie, and the knowledge of Simples; Chief Physician to the Queen-Mother of *Lewis XIII.*

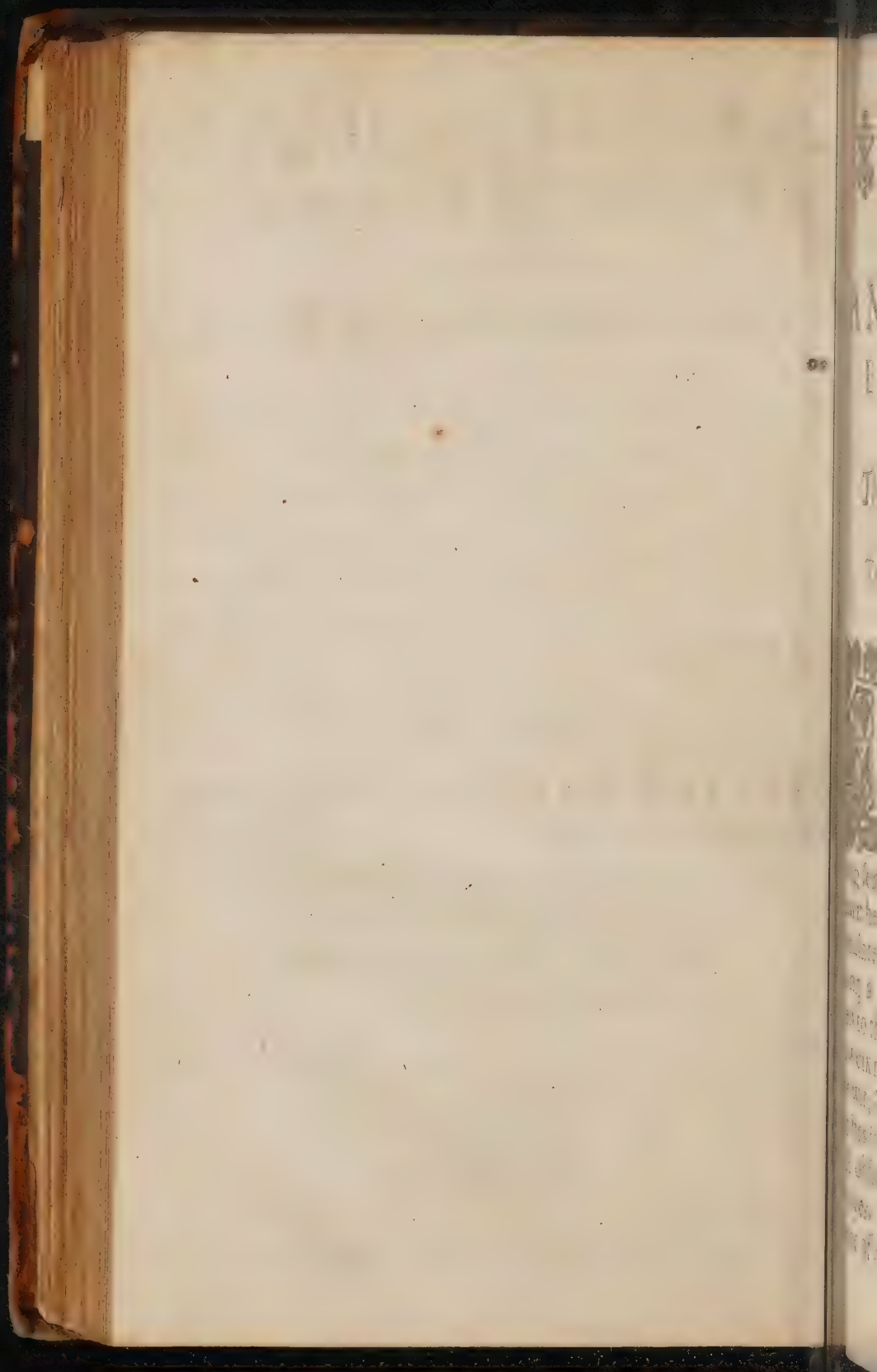
*The Author,*

**WILLIAM HARVEY**, an *Englishman*,  
Professor of Anatomie and Chirurgie  
in the College of Physicians at  
**L O N D O N**, and Doctor of  
Physick to the Kings most  
Excellent Majestie.



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*London, Printed by Francis Leach, 1653.*







The First  
**ANATOMICAL**  
**EXERCITATION**

Concerning  
*The Circulation of the Blood,*  
To JOHN RIOLAN.



Here did come forth not  
many moneths agoe a  
little piece of the most  
famous *Riolan's*, concer-  
ning Anatomie and Dif-  
eases; for which, as

being sent to me by the Author himself, I  
return hearty thanks: Seriously I do con-  
gratulate the felicity of that man in under-  
taking a thing very commendable. To  
open to the view the seats of all Diseases,  
is a work not to be atchiev'd but by a di-  
vine wit; Truly he undertook a hard task,  
that has set those Diseases, which are al-  
most obscure to our understanding, before  
our eyes. Such endeavours become the  
prince of Anatomists; for there is no Sci-

ence which has not its beginning from foregoing knowledge, nor any knowledge which is not beholding to sense for its original: For which cause the business it seeks and the example of so worthy a person required my pains. and did invite me in this manner to put forth and joyn my medicinal Anatomie, being chiefly fitted for Physicall uses, not with the same intention as he, by demonstrating the places of diseases, from the dead bodies of healthfull men, and rehearsing the divers sorts of diseases incident to those places, according to other mens opinions, which he ought to have seen there; but that I might undertake to relate from the many dissections of sick bodies and the most grievous and wonderfull diseases of dead persons, in what manner, and how the inward parts of them are chang'd, in place, bignesse, condition, figure, substance, and other sensible accidents, from their natural form and appearance, which all Anatomists commonly describ'd, and how diversly, and wonderfully they are affected. For as the dissection of healthfull and well habited bodies conduces much to Philosophie: so the right Physiologie, to the inspection of diseased bodies conduces chiefly to Pathological Philosophie. For the Physiologie, the contemplation of those things which according to Nature, is first to be known



by the Physician, for that which is according to Nature is right, and is rule both to itself and that which is amisse; by the light of which, errors and preternatural diseases being defin'd, Patuologie is more clear, and from Pathologie the use and art of administering Physick, and occasions of inventing many new remedies doe occur. Nor will any man beleieve how much in diseases, especially such as are Chronical, the inwards are chang'd, and what monstrous shapes of the inward parts are begotten by diseases: And I dare say the opening and dissection of one consumptive person, or of a body spent with some antient or venemous disease, has more enrich'd the knowledge of Physick, than the dissections of ten bodies of men that have been hang'd.

Yet doe not I disallow of the most famous and most learned Anatomist *Riolan* his purpose, but think it highly to be commended, as being very profitable for Physick, that he does illustrate the Physiologicall part; yet did I think that it would not be lesse profitable to the art of Physick if I should set clearly before your eyes to be seen, not only the places, but likewise the diseases of those places, and rehearse them, after I had well view'd and observ'd them, and from my many dissections declare my experience.

But such things in that Book concerning the Circulation of the blood found out by me, which are translated, and seem to reflect onely upon me, must first and chiefly be taken into consideration by mee. For so great a mans judgement, concerning such a weighty businesse, is not to be set at nought (who is undoubtedly thought the chief, and ringleader of all Anatomists of this age) but the opinion of him alone, is more to be weigh'd for commendation, than the verdicts of all others which shall either applaud or contradict me, and his censure more to be weigh'd and look'd upon. He then in his *lib. 3. cap. 8. Enchir.* acknowledges our motion of the blood in Animals, and takes part with us, and is of our opinion, as concerning the circulation of the blood: yet not altogether, and openly; for he says, *lib. 2. cap. 21.* That the blood in the pulmonary vein contained, admits no circulation, as the blood in the *vena cava*, and in *lib. 3. cap. 8.* That there is blood which is circulated, and circulatory vessels, wit, the *aorta* and the *vena cava*, yet denies that the branches of them have any circulation; *Because*, says he, *the blood running out into all the parts of the second and third region, stayes there for nutrition, nor does it flow back to the greater vessels, but being pluck'd back by force*



## *The circulation of the Blood.*

5

when the greater vessels are in great want of blood, or when it returns with a sudden force, or exstimulation, to the greater circulatory vessels. And so a little after. Whether or no the blood of the veins, does perpetually or naturally ascend, or whether it returns to the Heart, or whether the blood of the Arteries do descend, or go from the Heart, yet if the lesser veins of the arms and leggs be empty, the blood of the veins in succession filling the empty places, may descend, which (sayes he) I have clearly demonstrated against Harvey and Wallæus. And because daily experience and the authority of Galen does confirm the *Anastomosis* of the veins & arteries, & the necessity of the Circulation of the blood; You see, sayes he, how the circulation of the blood comes about, without the confusion of humors; or the perturbation of antient medicine.

By which words it is known, for what cause the most famous man would partly acknowledge, partly deny the Circulation of the blood, and why he endeavours to build a reeling and tottering opinion of Circulation. Lest, forsooth, he should destroy the antient Physick, and not mov'd by truth, which he could not chuse but see, but rather for fear he should violate the antient rules of Physick, or perchance, lest he should seem to resume or retract that Physiologie which in his *Anthropolo-*

*gia* he had publish'd before. For the Circulation of the Blood does not destroy the antient Physick, but furthers it; rather it shows the Physiologie of Physicians, and the speculation of natural things, and disallows the Anatomical doctrine of the use and action of the *heart, lungs,* and the rest of the intrals; and that these things are so, will appear partly out of his own words, partly out of those things which I shall here set down; namely, that the whole blood, in whatsoever part of the body living it be, does move and shift place (as well that which is in the greater *veins,* and their *branches* and *fibers,* as that in the porosities of the parts in any region of the body) does flow to the *heart,* & flow from the *heart,* without interruption incessantly, and never continues in one place without damage; though I do not say, but in some places it moves slower, some faster.

First then, the most learned man denies only that the blood contain'd in the *Porta* does circulate, which he could neither have denied nor disapproved of, if he had not pass'd over the force of his own argument: for he says *lib. 3. cap. 8.* *in every pulsation the heart receive one drop of blood, which it expels into the aorta and does make two thousand pulsations in an hour, there must needs a great deal of blood*



pass through. He is likewise forc'd  
to affirm the same of the *mesenterie*, since  
through the *celiacal arterie*, and the *me-  
senterial arteries*, there is thrust in more  
than one drop of blood at every pulsati-  
on, and is forc'd against the *mesenterie* and  
its *veins*: insomuch that it must either go  
out according to the just proportion of  
that which enters, otherwise the branches  
of the *Porta* would burst at last; nor can  
it (for the resolution of this doubt) be pro-  
bably said, or possibly be, that the blood  
of the *mesenterie* should vainly, and to no  
purpose, ebb and flow through these *arte-  
ries*, like an *Euripus*; nor the relapse  
from the *mesenteris* by those passages  
and transplantation by which he would  
have the *mesenterie* disgorge it self  
into the *aorta*, likely to be true; nor can it  
prevail against that which is entering by  
contrary motion; nor can there be any vi-  
cissitude, where it is most certain that  
without interruption, and incessantly,  
there is an influx; but is compell'd by the  
same necessity, by which it is certain, that  
the *heart* doth thrust forth the blood a-  
gainst the *mesenteria*. Which is most ma-  
nifest; for otherwise, by the same argu-  
ment, they would overthrow all Circula-  
tion of the blood, if thus he should, with  
the same likelihood of truth, affirm that  
too in the *ventricles* of the *heart*, namely

in the *Systole* of the *heart* the blood driven into the *aorta*, and in the *Diastole* returns, and the *aorta* disburthens it into the *ventricles* of the *heart*, as it *ventricles* again into the *aorta*, and neither in the *heart* nor in the *mesenteric* should there be any circulation, but a flux and reflux, by turns, is turned up and down with needlesse labour: Therefore if of necessity in the *heart* is proved the circulation of the blood, for the reason fore said prov'd by himself, the same form of argument takes place likewise in the *mesenteric*; but if there be no circulation in the *mesenteric*, neither is there in the *heart*; for both these assertions, namely this of the *heart*, that of the *mesenteric* hangs upon the force of the same argument, onely changing the words, and establish'd, and falls in like manner.

He sayes, that the Sigma-like *portals* do hinder the regresse of the blood in the *heart*, but there are no *portals* in the *mesenteric*.

I answer, neither is this true; for in the *splenick* branch, as likewise sometimes in others, there are found *portals*. Besides *portals* are not all times requisite in the more profound *veins*, nor are they found in the deep *veins* of the joints, but rather in the skin *veins*; for where the blood flowing out of the lesse branches is pro-



### *The Circulation of the Blood.*

naturally to come into the greater, by the compression of the *muscles* about it it is sufficiently hinder'd from return, but where the passage being open, it is forc'd; What need is there there of *portals*? But how much blood at every pulsation is forc'd into the *mesenterie*, is reckoned according to the same account, as if with an indifferent *ligature* you should in the *carpus* bind the *veins* coming out of the hand, and entring into the *arteries*; (for the *arteries* of the *mesenterie* are greater than those of the *carpus*) if you tell at how many pulsations the vessel and your whole hand swell to their greatest bignesse, dividing and making a subduction, you shall find much more than one drop of blood come in at every pulsation, notwithstanding the *ligature*; nor can it return, but rather that in filling the hand it forcibly distends and swells it, we may by calculation gather, that the blood enters the *mesenterie* in the same quantity, if not in a greater, by how much the *arteries* of the *mesenterie* are greater than those of the *carpus*. And if any should but see and think with himself, with what difficultie and pains, compressions, *ligatures*, and severall means the blood is staid, that leaps forcibly out of the least *arterie* which is cut or broken, with what strength (as if it were shot out of a spout)

spout) it throws off, and drives away or passes through all the bindings, I think he would scarce beleieve that any part of blood which only enters, could against this impulsion and influx passe back again being not able to drive it back with force. For which cause, considering these things with himself, I beleieve it would not enter his mind to imagin that the blood out of the *veins* of the *porta* could cree back by these same wayes, and so disburthen it self into the *Mesenterie*, against so forcible and strong an influx into the *series*.

Moreover, if the most learned man beleieve not that the blood is mov'd and chang'd by circular motion, but being in the same, it stands and mantles in the branches of the *mesenterie*; he seems to suppose, that there is a two-fold blood divers, and serving to divers uses and ends and therefore it is of divers natures in the *vena porta* and *cava*, because one of them for its preservation needs circulation, the other needs not, which neither does it appear, nor does he demonstrate it to be true.

Besides the most learned man addeth in his *Enchirid.* lib. 2. cap. 18. *A fourth* of vessels to the *Mesenterie*, which are called the *Vena Lactea* (invented by *Asselin*) which being set down, he seems to infer



all the nutriment being drawn through them is carried to the liver, the forge of blood, which being there concocted and changed into blood, (he says in lib. 3. cap. 8.) it is carried to the left ventricle of the heart, which being granted, sayes he, all the scruples which were antiently motion'd concerning the distribution of the Chylus, and of the blood through the same conduit, do cease, for the *Vena Lactea* carry the Chylus to the Liver, and therefore these conduits are apart, and can be obstructed apart. But indeed I would fain know how this can be demonstrated to be true; If this milk be transfus'd and passe into the liver, how shall it get thence through the *cava* into the ventricle of the heart? (Since the most learned man denyes that the blood contained in the numerous branches of the *porta* and the liver can passe, that so circulation may be made) but more especially since the blood seems to be a great deal fuller of spirit, and more penetrative than the milk or chylus, which is contain'd in these vessels, and is hitherto impell'd by the *arteries* that it may find out some way for its self.

The most learned man makes mention of a certain Treatise of his concerning the Circulation of the blood, I wish I could see it, I might perchance recant.

But if the most learned man thought it  
more

more fit to place the circular motion of the blood in the *veins* of the *porta*, and branches of the *cava*, (as he says in his Book Chap. 8. *In the veins the blood doth perpetually and naturally ascend or return to the heart, as likewise that which is in the arteries descends and departs from the heart.* I say, I do not see, but upon this position all difficulties which were objected of old of the distribution of the *Chylus*, blood, through these same conduits, should likewise cease, that hence forward I should not need to enquire apart for, to set down vessels for the *chylus*; seeing as the *Umbilical veins* do draw their nutritive juice from the liquors of the egg and carries it to the nourishing and augmentation of the Chick whilst it is yet an *Embryon*, so do the *meseraick veins* suck the *chylus* from the *intestines*, and carry it to the *liver*, and what hinders us to assert that it does the like in those of riper ages for all difficulties cease, when there are not two contrary motions supposed in the same vessels; but that we do suppose there is one continued motion in the *meseraicks* from the *intestines* to the *Liver*.

I shall tell you in another place what to be thought of the *venæ Lactææ*, where I shall speak of milk found in several parts of creatures new born, especially in man kind, for it is found in the *mesenteric* and



all its glandules, as also in the *chymus*; likewise in the arm-pits and paps of Children; the Midwives milk out the blood for their health as they beleeeve.

But moreover it pleas'd the most learned *Riolan*, not only to deprive the blood contain'd in the *mesenteric* of circulation, but also he affirms, that neither the branches of the *vena cava*, or its *arterie*, or any part of the second or third region admits of circulation, so that only he calls the *vena cava* & the *aorta* circulatory vessels, for which in his 3 Book Chap. 8. he gives a very faint reason, *Because the blood*, sayes he, *flowing into all parts of the second and third region remains there for nourishment nor does it flow back to the greater vessels, unless it be revulsed by the force and want of blood in the greater vessels, or flow back, being stirr'd with a sudden force, to the circulatory vessels.*

It is indeed of necessity, that the portion which passes into nourishment, should remain, for otherwise it should not nourish unless it be assimilated, & stay there, in lieu of that which is lost, & so become one: but it is not needfull, that the whole influx of blood should remain there for the conversion of so little a portion; for every part does not use so much blood for its nourishment, as it contains in its *veins*, *arteries*, and *porosities*, nor is it necessary  
in

in his afflux and reflux that it should leave no nourishment within it; wherefore it is not necessary that for nutrition it should all stay, but likewise the most learned man himself, in the very same book in which he affirms this, does seem everywhere almost to affirm the contrary, especially where he sets down the circulation in the brain, and by circulation (saying he) the brain does send back blood to the heart; and so the heart is refrigerated. After which sort likewise, the remote parts may be said to refrigerate the heart, when also in fevers, when the parts about the heart are grievously scorched and inflamed with feverish heat, laying naked the joints, and throwing off the cloaths, the people endeavor to cool their heart, which (as the most learned man affirms of the brain) the blood being refrigerated by the allay of its heat, does then go to the heart through the veins, and does refrigerate it. Whence the most learned man seems to insinuate a kind of necessity, that as from the brains, so there is a circulation from all the parts, otherwise than before he openly declar'd. But indeed he cautions and ambiguously affirms, That the blood does not flow back from the parts of the second and third region, unless, saying, being revuls'd by the force and great quantity of blood in the bigger vessels, or that



does by a sudden forcible motion flow back to the greater circulatory vessels, which is most true, if these words be understood in a true sense; for by the greater vessels, in which he says want causes a reflux, I believe he understands the *vena cava*, or the circulatory *veins*, not the *arteries*; for the *arteries* are never emptied, but into the *veins*, or *pores* of the parts, but they are continually stuff'd full by the pulsie of the *heart*. If all the parts did not incessantly refund blood in abundance into the *vena cava*, and the circulatory vessels, out of which the blood very suddenly passes, and hastens to the *heart*, there would quickly be a great want of blood. Besides that, the blood which is contained in all the parts of the second and third region, by the force of the blood directed and driven by every pulse, is forc'd out of the pores into the *veins*, out of the branches into the greater vessels, as likewise by the motion and compression of the parts adjacent; for that which is contain'd is thrust out by every thing containing it, when it is press'd and streightened: so by the motion of the *muscles* and the joints, the branches of the *veins* passing between being press'd and streightened, thrust the blood contain'd in the lesser vessels into the greater.

But it is not to be doubted, that the  
S blood

blood is continually and incessantly driven, and comes with force from the *arteries*, and never flows back; if it be admitted, that in every pulse all the *arteries* together are distended by the propulsion of blood, and that the *Diastole* of the *arteries*, as the most learned man confesses, is from the *Systole* of the heart; nor does the blood once gone forth, return into the *ventricles* of the heart, by reason that the *portals* are shut, if (I say) the most learned man do believe these things, as it seems he does, it will easily be understood in every part of what region soever; what stuffing or impulsion the blood and them contained is forcibly thrust down.

For so far as the *arteries* beat, so it reaches the influx and the force, wherefore it is felt in all parts of every region; for there is a pulse every where in the tips of our fingers, and under the nails, nor is there any part in our whole body, either before with boil or fellon, which does not feel the pricking motion of the beating of the *arterie*, and its endeavour to solve the *continuum*.

But further, it is manifest, that the blood does make a regresse in the pores of all parts, in the skin of the hands and feet, sometimes in great frost and cold season we see the hands and joints, especially in boys, so cold, that at the very touch it



do almost resemble the coldnesse of Ice,  
and are so benumbed and stiff, that there  
is scarce any life in them, nor motion. and  
yet in the mean time they are full of  
blood seeming red or blew, which parts  
an again by no weans be warm'd, unlesse  
by Circulation that refrigerate blood be  
thrust out, and in its place, new, warm, and  
spirituous blood flowing in do foment and  
re-warm the parts, and restore to them  
motion and sense; for they should never  
be renew'd or restor'd by external heat,  
no more than the members of dead per-  
sons, unlesse some internal influent warmth  
did refresh them. This indeed is the chief  
use & end of the Circulation of the blood,  
for which cause, the blood by its continual  
course, and perpetual influence, is driven a-  
bout; namely, that all the parts depending  
upon it by their first innate warm moisture  
might be retain'd in life, and in their own  
vital and vegetative essence, and perform  
all their functions, whilst (as the Natural-  
ists say) they are sustain'd and actuated  
by natural heat, and vital spirits; so by the  
help of two extremities, heat and cold,  
the temper of the bodies of creatures is  
kept in its mediocrity: for as the breathing  
of air does temper the too much heat of  
the blood in the *lungs*, and in the centre of  
the body, and causes the eventilation of  
stagnating fumes; so also the blood being  
hot,

hot, and cast out through the *arteries* in the whole body, does foment and nourish the extremities in living creatures, and renders them to be extinguish'd by the force of outward cold.

Therefore it were unjust and wonderful, if every little part of what region ever should not enjoy the benefit of transmutation and circulation of blood, for whose sake Circulation seems chiefly to be appointed by Nature. Therefore, that I may conclude, for you how the Circulation of the blood is perform'd without perturbation or confusion of the humors, in all the body, and in every part, both in the greater and in the lesser vessels, and that by necessity, and for the benefit of all the parts, without which being cold and impotent, they could not be restor'd, or remain alive. It is enough, because its clear, that all influence of servative heat does come through the *arteries*, and is done by circulation.

For which cause most learned R. seems to me, when he sayes, that in some parts there is no Circulation, to say rather officiously, than truth; to wit, he might please most men, and oppose the body, and that he rather wrote humbly, than gravely, in the behalf of the truth. As he likewise seems to do (*lib. 3. cap.* when he would rather have the blood



Come into the *left ventricle* through the *Septum* of the *heart*, through uncertain and hidden passages, than through the large and most open vessels of the *lungs*, being made with *Portals* artificially to hinder its return. I desire to see the reason of the impossibility and inconvenience which he says he propounded elsewhere. It is a wonder, since the *Aorta* and *vena Arteriosa*, are of the same bignesse, constitution, and frame, that their function should not be the same. But that is very improbable that the great River of the whole masse of blood should in so great abundance go into the *left ventricle* by so blind and small a winding of the *Septum*, which should answer both to the entrie from the *vena cava* in the right side of the *heart*, and also its egress from the *left*, which do both require such wide *orifices*. But he has likewise produc'd these things staggeringly, for in *lib. 3. ca 6.* he ordains the *lungs* as a link or passage from the *heart*, and he says, *The lungs are affected by that blood which passes through, whilst its filth flows together with that blood*; so he says likewise, *That the lungs acquire corruption by distemper'd, and ill-condition'd intralls, which furnish the heart with impure blood, whose fault the heart cannot help, but by many circulations.* He like-

*Anatomical Exercitations, concerning*  
 wise in the same place, concerning letting  
 of blood, and shortnesse of breath, & com-  
 munication of the *veins* with the vessels  
 the *lungs*, says against *Galen*, If it be true  
 that the blood does naturally passe from the  
 right ventricle of the heart to the *lungs*, that  
 it may be carryed to the left ventricle, and  
 so to the *aorta*; and if the Circulation of  
 blood be admitted, who sees not in the ad-  
 diseases of the *lungs*, that the blood flows thither  
 in greater abundance, and oppresses the  
*lungs*, unlesse they be first largely emptied  
 every part taking a share to ease them; Which  
 was *Hippocrates* advice, from all parts of the  
 body, head, nose, tongue, arms, feet, to take  
 away the blood, that the quantity of  
 might be impaired, and that it might be re-  
 vulsed from the *lungs*, and so draws out  
 blood till the body was quite without blood.  
 He says likewise, The Circulation being  
 suppos'd, the *lungs* are easily emptied  
 breathing a vein. If this counsel be rejected  
 I see not how it can be revuls'd from them  
 for if it flow back through the *vena arteria*  
 into the right ventricle, the *Sigmoidal* p  
 tals hinder it, and the three-pointed port  
 hinder the regress out of the right ventricle  
 into the *vena cava*. Therefore by Circulation  
 the blood will be exhausted, by cutting  
 veins of the arms and feet. And likewise  
*Fernelius* his opinion in the affections of  
*lungs* is destroy'd, that blood is rather to



taken out of the right arm than out of the left, for the blood cannot return into the vena cava, unlesse it break through two gates and bars which are placed in the heart.

He addes moreover in the same place, (lib. 3. cap. 6.) If the Circulation of the blood be admitted, and that it doth pass often through the lungs; and not through the middle of the Septum of the heart, there is a two-fold Circulation of the blood to be assigned, one of which is perfected by the heart and the lungs, whilst the blood leaping out from the right ventricle of the heart is carried through the lungs, that it may come to the left ventricle of the heart; for leaping out from the same inward part, it returns to it, then by another larger circulation flowing out of the left ventricle of the heart, it goes about the whole body, and runs through the arteries and veins to the right ventricle of the heart.

The most learned man in this place might have added the third circulation, which is a very short one, out of the left ventricle into the right, drawing about part of the blood through the coronall arteries and veins, by its branches, which are distributed about the bodie, walls, and septum of the heart.

He says, *He that admits of one circulation, cannot deny the other.* So might he have added, nor can he refuse the third.

For to what purpose should the *coronary arteries* beat in the heart, if they did not drive blood thither? and why should the *veins*, (whose function and end it is to receive blood put into them by the *arteries*) but that they might draw blood from the heart? Moreover in the orifice of the *Coronary arterie* (as the learned man himself confesses, in his third Book and his ninth Chapter,) there is a *portal* which forbids all entrance, and is patent to egress: therefore truly he cannot but admit of the third Circulation, who likewise admits of another universal one, and that the blood does likewise passe through the *lungs* and the brain, ( *lib. 4. cap. 2.* ) For neither can there be an admittance of blood by pulsation, in all parts of every region, nor regresse by the *veins* after the same manner, and therefore he cannot deny, but that the parts admit of Circulation.

Therefore it is clear from these very words of the most learned man, what his opinion is, both of the Circulation of the blood through the whole bodie, as likewise through the *lungs*, and the rest of the parts; for he that admits of the first Circulation, it is clear that he does not reject the other: For how can it be, that he who has admitted of another Circulation through the whole body so often, and throu



through the greater circulatory vessels, should deny that universal Circulation in any of the branches or parts of the second or third region? As if all the *veins* & those greater circulatory vessels, as he calls them, were not number'd by himself, and by all others, amongst the vessels of the second region. Is it possible that there should be circulation through the whole body, and not through all the parts? and therefore where he denies it he does it very stammeringly, and only staggers and palliates in his negations; there where he affirms he speaks understandingly and as becomes a Philosopher, and as a skilful Physician and an honest man, gives his advice in this case, that in the dangerous diseases of the *lungs* the letting of blood is the only remedy, against *Galen* and his beloved *Fernelius*: in which thing if he had been doubtfull, far be it from a Christian and so learned a man, to recommend his experiments to posterity, to procure death, and the hazzard of mens lives, or that he should recede from *Fernelius* or *Galen*, men in high esteem with him. Therefore whatsoever he has denyed of the Circulation in the *mesenterie*, or any other part, in favour of the antient Doctrine of Physick, or the *Vena Lactea*, or for any other regard, it is to be attributed to his civility and modesty, and to be pardoned.

I think it does already appear clear enough, both from the words and the arguments of the most learned man himself that there is a circulation every where and that blood wheresoever it is, does change place, and passe through the *veins* to the *heart*; and the most learned man seems to be of the same opinion with mee. Therefore it needs not, yea it were superfluous to bring hither my arguments which I have published in my Book concerning the motion of the blood, for the further confirmation of this truth, which are taken both from the frame of the vessels, placing of the *portals*, and other experiments and observations; especially since I have not as yet seen the most learned mans Treatise of the Circulation of the blood, nor as yet any of the most learned mans Arguments, but only a bare negation, by which being induced, he should reject the circulation in the regions and vessels, which he allows to be universal in most of the parts.

It is indeed true, that I did find out the authority of *Galen*, and by dayly experience to be a *refugium* the *Anastomoses* of the vessels, yet so great a man as he is so diligent, so curious, so expert an Anatomist, should first have laid open and shown *Anastomoses*, and those visible and open ones, and whirlpools proportionable



to the imperuous stream of the whole blood, and the orifices of the branches, ( from which he has taken away circulation ) before he had rejected those which were most probable and most open. He was oblig'd to demonstrate and declare where they are, how they are fram'd, whether they are not onely fit for the intromission of blood ( as we see the *arteries* inserted in the bladder ) and not for the return of it, or what other way soever they had been. But perchance I speak too boldly, for neither the learned man, nor *Galen* himself, could by any experience ever behold the sensible *Anastomoses*, or ever could demonstrate them to the sense.

I did look alter them with all possible diligence, and was not at a little charge and pains in the search of the *Anastomoses*, yet could I never find that any vessell, namely the *arteries*, together with the *veins*, were joyn'd by their *orifices* : I should willingly learn from others who ascribe so much to *Galen*, that they dare swear all which he says. Nor is there any *Anastomosis* in the *liver*, *milt*, *lungs*, *reins*, or any other of the intrals, although I did boyl them till the whole *Parenchyma* was made mouldering, and like dust was shaken off, and taken away with the point of a needle, from all the *fibers* of the vessels,

*Anatomical Exercitations, concerning*  
 fels, so that I could see the *fibers*, and the  
 last grains of every division. I dare there-  
 fore boldly affirm, that neither the *vena*  
*porta* has any *Anastomoses* with the *cava*  
 nor the *veins* with the *arteries*, or the *cap-*  
*pillar branches* of the pore of the *choleric*  
*bagg*, which are dispers'd about all the flae  
 of the *liver* with the *veins*. Only this you  
 may observe in a fresh *liver*, that all the  
 branches of the *vena cava* which creep  
 through the whole bunch of the *liver*  
 have *unicles* pierc'd with many holes  
 like a sieve, as it is in a sink, fram'd so for the  
 receiving of the blood which falls down.  
 The branches of the *Porta* are not so, but  
 are divided into stems, and how that both  
 the divisions of these vessels, the one in the  
 flat, the other in the gibbous part, doe  
 run round to the very furthest rising  
 of that intrall without any *Anasto-*  
*moses*.

Only in three places doe I find that  
 which is equivalent to an *Anastomosis*.  
 There rises in the brain, from the *soporal*  
*arteries* creeping down into the *Basis*, ma-  
 ny and unintangled *fibers*, which after-  
 wards make up the *plexus chorois*, and pas-  
 sing through the *ventricles* doe at last end  
 in the third receptacle, which performs  
 the office of a *vein*. In the *spermatic*  
*vessels*, commonly call'd preparatory, lit-  
 tle *arteries* drawn from the great *arteries*  
 doe



do adhere to the *veins* preparatory aforesaid, which they accompany, and at last are so receiv'd within their *Tunicle*, so that at the first they seem both to have one and the same, so that when they end at the upper part of the *testicles* where that part passes forth into a point, which is called the varicous and vine-like body, we know not what to call them, *veins* or *arteries*, or the ends of both. As likewise the last appearances of the *arteries* which goe to the *Umbilical vein*, are obliterated in the *Tunicles* of that *vein*.

What doubt is to be made, if through such gulphes, the little branches of the *arteria magna*, swoln with the impulsion and instuffing of blood, could be eas'd of so great and so conspicuous a stream? Nature at least would never have denyed us visible and sensible passages, sincks and whirlpools, if she had had intention to have turned all the flux of the blood thither, and by that meanes have deprived the lesser branches, and the solide parts of the benefit of the influx of blood.

Lastly, I will set down one experiment, which seems to be sufficient for the clearing of the *Anastomoses*, and for the overthrowing of their use,  
and

*Anatomical Exercitations, concerning*  
and of the passage of the blood, and re-  
turn of it out of the *veins* into the *ar-*  
*teries*, by those wayes.

Opening the breast of any creature  
and tying the *vena cava* by the heart  
so that nothing can passe that way im-  
to the heart, and presently cutting the  
*jugular arteries*, not touching the *veins*  
on neither side, If by giving vent you  
see the *arteries* emptied, and not the  
*veins* too, I hope it will be clear that  
the blood is carryed out of the *veins*  
into the *arteries*, no where but through  
the *ventricles* of the heart. Other-  
wise (as *Galen* has observ'd) in a little  
space we should see the *veins* emptied,  
and destitute of blood by the efflux out  
the *arteries*.

In what remains, *Riolan*, I both con-  
gratulate my self and you, my self for  
your opinion, with which you have a-  
dorn'd my Circulation, as likewise  
return to you exceeding thanks for your  
learned, neat, succinct piece which you  
sent to me, than which there is nothing  
more elegant, and I both owe and desire  
to return deserv'd commendation, but I  
confess I am not able for such a charge.  
For I know the name of *Riolan* will afford  
more praise to me in its subscription, than  
my prayes, which I wish as great as may  
be, can do to his *Enchiridion*. The famous  
books

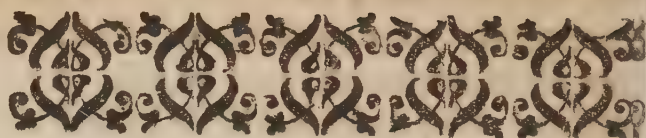


book shall outlive all memory, and shall recommend your worth to Posterity when all Monuments shall perish. To it you have very handsomly adjoyn'd the Anatomy of Diseases, and have very profitably enrich'd it with a new Treatise concerning the Bones. May you, most worthy Man, continually increase in this your worth, and love me, who wish that you may be both happy and long liv'd, and that your most famous writings may be an eternall Commendation to you.

*William Harvey.*

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A N O-



ANOTHER  
EXERCITATION,  
TO  
JOHN RIOLAN.

*In which, many Objections against the  
Circulation of the Blood are refuted.*



Most learned Riolan, By the help of the Press many years ago, I published a part of my labour : But since the birth-day of the Circulation of the Blood, almost no day has past, nor the least space of time, in which I have not heard both of the good and evill of the Circulation of the Blood which I found out : Others rail at it, as a tender babe unworthy to come into the light ; Others say, that its worthy to be foster'd, and favour my writings, and defend them ; Some with great disdain oppose them ; Some with mighty applause



plause protect them ; Others say , that I have abundantly by many experiments, observations, and ocular testimony, confirm'd the Circulation of the blood , against all strength and force of arguments ; Others think it not yet sufficiently illustrated, and vindicated from objections : But there are who cry out, that I have affected a vain commendation in dissection of living creatures, and do with childish slighting dispraise and deride at Frogs and Serpents, Gnats, and other more inconsiderable creatures brought upon the Stage, and refrain not from ill language. But I think it a thing unworthy of a Philosopher and a searcher of the truth, to return bad words for bad words, and I think I shall doe better and more advised, if with the light of true and evident observations I shall wipe away those Symptomes of incivility.

It cannot be eschewed but doggs will bark and belch up their surfets ; nor can it be help'd, but that the Cynicks will be amongst the number of the Philosophers : but we must take a speciall care that they doe not bite, nor infect us with their cruel madnesse, or lest they should with their doggs teeth gnaw the very bones or principles of truth.

Detractors, Momes, and writers staind with railing, as I never intended to read  
T any

any of them (from whom nothing of solidity. nor any thing extraordinary is to be hop'd for, but bad words) so did I much lesse think them worthy of an answer. Let them enjoy their own cursed nature. I beleeve they will find but a few favourable Readers; neither does God give wisdom to the wicked, which is the most excellent gift, and most to be sought for. Let them rail on still, till they be weary (not asham'd) of it.

If you will enter with *Heraclitus* & *Aristotle* into a work-house (for so I will call it) for inspection of viler creatures, come hither, for the immortal gods are here likewise; and the great and Almighty Father is sometimes most conspicuous in the least and most inconsiderable creatures.

In my book concerning the motion of the heart and blood in creatures, I have choise out those things out of my many other observations, by which I either thought that errours were confuted, truth was confirm'd; I left out many things as unnecessary and unprofitable, which notwithstanding are discernable by dissection and sense; of which I shall now adde some in few words, in favour of those that desire to learn. The great authority of *Galen* is of so much account with every body, that I see many make a dis-



culty as concerning that experiment of *Galen* of the *ligature* of the *arterie* above the pipe, thrust within the concavity of the *arterie*, by which it is demonstrated, that the pulse of the *arterie* comes from the facultie pulsifick, and that it is transmitted from the *heart* by the *tunicles*, and not by the impulsion of the blood within the Concavities; and therefore that the *arteries* are stretch'd as bellowes, not as baggs.

This experiment is mentioned by *Vesalius*, a man very skilfull in Anatomy, but neither *Galen* nor *Vesalius* says, that they tryed this experiment, which I did; only *Vesalius* prescribes it, and *Galen* counsells it to those that are desirous to find out the truth, not thinking, nor knowing the difficulty of that businesse, nor the vanity of it when it is done, since although it be perform'd with all manner of diligence, it makes nothing to the confirmation of that opinion, which affirms That the *tunicles* are the cause of pulsation, but rather shows That it is set a-work by the impulsion of the blood. For so soon as above the reed or pipe you have with a band tyed the *arterie*, the *arterie* above the *ligature* is presently dilated by the impulsion of the blood beyond the mouth of the pipe, from whence both the flux is stop'd, and the impulsion reverberated, so that

the *arterie* under the band does beat with very little appearance, because the force of the passage of the blood does not well assist it, because it is return'd above the gature; but if the *arterie* be cut off below the pipe, you shall see the contrary, from the leaping of the blood which is thrown out, and driven through the pipe, as in an Aneurism I have observ'd to come from the exesion of the *tunicles* of the *arterie*, the (whilst the blood is containd within the membranes) hath a contentive vessel of flux prænatually made, not of the dilatation of the *tunicles* of the *arterie*, but of the circumposition of the membrane and flesh. You shall see the inferiour *arteries* beyond the Aneurism beat very weakly, whilst above and especially in the Aneurism it self, the pulsations appear great and vehement although we cannot there imagine, that the impulse or dilatation is made by the *tunicles* of the *arterie*, or by communication of the faculty of the *Cy*, but meerly by the impulsiion of the blood.

But that the error of *Vesalius*, and the small experience of others may the more clearly appear, who affirm (as they imagine) that the part under the pipe does not beat when the band is tyed, I speak by experience, if you make the experiment rightly, that it will; and whereas they



that upon the untying the band the *arteries* below do beat backwards, I say that the part below beats lesse when you have untied it, then when it is tyed.

But the effusion of blood which leaps out of the wound confuses all, and makes the experiment vain and to no purpose, so that there can be no certainty demonstrated, as I said, by reason of the blood. But if ( and this I know by experience ) you lay open the *arterie*, and hold with your finger close that part which you cut, you may at your pleasure try many things which will evidently make the truth appear to you. First, you shall feel the blood, being forc'd, comming down into the *arterie*, by which you shall see the *arterie* dilated; as likewise you may squeeze out and let go the blood as you please: If you open a little part of the *orifice* and look narrowly to it, you shall see the blood at every pulse to be thrown out with a leaping, and as we said in the opening of an *arterie*, or in the *perforation* of the *heart*, you shall see the blood to be thrown out in every contraction of the *heart*, in the dilatation of the *arterie*.

But if you suffer it to flow with a constant and continuall flux, and give it leave to break out, either through the pipe, or by the open *orifice*, in the streaming of

it both by your sight and by your touce you shall find all the stroaks, order, vehemency, and intermission of the *heart*; just as you might feel in the pulse of your hand water squirted through a syringe : as divers and severall shootings, so you may perceive both by your sight and by its motion, the blood leaping out with a varying and unequall force. I have seen sometimes in the cutting of the *jugular arterie* break out with such force, that the blood being forc'd against the hand, driven by its reverberation and refraction, fly back four or five foot.

But that this doubt may be more cleared that the pulsifick force does not flow through the *Tunicles* of the *arteries* from the *heart*, I have a little piece of the *arterie* descendant, together with two collateral branches of it, about the length of a span, taken out of the body of a very worthy Gentleman, which turn'd to be bone like a pipe, by the hollow of which whilst this worthy Gentleman was alive the blood in its descent to the feet did agitate the *arteries* by its impulsions; which case neverthelesse, although the *arterie* were in the same condition as if had been bound or tyed above the little conduit-pipe, according to the experiment of *Galen*, that it could not either be dilated in that place, nor streightned like



pair of bellows, nor from the *heart* derive its pulsifick force, to the inferior and lesser *arteries*; nor yet carry through the solid substance of the bones that faculty which it had not receiv'd; yet I very well remember that I often observ'd whilst he was alive, that the pulse of the inferiour *arterie* did move in his legs and feet: wherefore it must needs follow, that in in that worthy Gentleman the inferiour *arteries* were dilated by the impulsion of the blood, like baggs, and not like bellows, by the stretching of the *tunioles*. For there must needs arrive the same inconvenience, and interception of the pulsifick faculty, the *tunicle* of the *arterie* being wholly converted into a conduit or pipe of bone, as might arrive from the reed or pipe which was tyed, that the *arterie* might not beat.

I knew likewise in another worthy and gallant Gentleman, the *aorta* and a part of the great *arterie* near the *heart*, turn'd into a round bone. So *Galen's* experiment, or at least one answerable to it, being not found out by industry, was found out by chance, and does manifestly evidence, that the interception of the pulsifick faculty is not intercepted by the construction or *ligature* of the *Tunioles*, so that by that means the *arteries* cannot beat; and if the experiment which *Galen*

prescribes, were rightly perform'd by any  
 it would refute the opinion which *Vesalius*  
 thought from thence to have confirm'd  
 Yet for this cause do we not deny all mo-  
 tion to the tunicles of the *arteries*, but  
 do attribute that to it which we grant to  
 the *heart*, namely, that there is a *coarctation*  
 and a *Systole* in the *tunicles* them-  
 selves, and from their distension a regress  
 to their naturall constitution. But in  
 this is to be observ'd, that they are not  
 dilated and streightned for the same  
 cause, nor by the same instrument, but by  
 severall, as you may observe in the motion  
 of all the parts, and in the *heart*; it  
 is distended by the *ear*, contracted by it-  
 self, so the *arteries* are dilated by the  
*heart*, and fall of themselves.

So you may make another experiment  
 after the same manner. If you fill two  
 sawcers of the same measure, one of them  
 with *arterial blood* which leaps out, the  
 the other with *venal blood*, drawn out of a  
*vein* of the same Animal, you may pre-  
 sently by your sense, and afterwards too  
 when both the bloods are grown cold  
 observe what is the difference betwixt  
 both the bloods, against those who do  
 fancy another sort of blood in the *arteri-  
 es* than is in the *veins*; namely they  
 do ascribe to the *veins* a fresher sort of  
 blood, I doe not know which way boy-  
 ling



ling or blown up, swelling or bubbling, (like to honey or milk upon the fire) and so taking up more room.

For if the blood which is driven out of the *left ventricle* into the *arteries* should be leaven'd, so as to be blown up, and foam after that manner, so that a drop or two should fill all the concavity of the *aorta*, no doubt it would when it fell again return to the quantity of some few drops (which cause some do allege for the emptiness of the *arteries* in dead men) and the same would be seen in the *cotyla* full of *arterial* blood; for so we find that it comes to passe in the cooling of milk or honey. But if in either *cotyla* the blood be found of the same colour, and congealed, of a not much different consistence, and squeezing out the whey after the same manner, and if it take up the same room both when it is hot and when it is cold, I think it will be a sufficient argument to gain any mans belieef, and to confute the dreams of some, that there is neither in the *left ventricle* any sort of blood differing from that of the *right*, (as you may find out both by sense and reason) for you must needs likewise affirm, that the *vena arteriosa* should equally be distended with one drop of blood foaming up, and therefore that there is just such bubbling and leaven'd blood in the *right* as in the

the *left*, seeing the entry of the *vena arteriosa*, and the egress of the *aorta*, is equi-  
pollent and equall.

Three things are chiefly ready to breed  
this opinion of the diversity of blood.  
One is, that in the cutting of an *artery*  
they see brighter blood drawn out; An-  
other is, that in the dissection of dead bo-  
dies they find both the *left ventricle* of  
the *heart* and all the *arteries* so empty.  
A third is, that they imagine that the *ar-  
terial blood* is more spirituous, and more  
replete with Spirits; and therefore they  
think that it takes up more room: This  
cause and reasons of all which things  
why they come to be so, by inspection  
perceiv'd.

First, inasmuch as concerns the colour  
always and every where blood comming  
through a narrow hole, is as as it were  
strained and becomes thinner, and the  
lighter part of it, and which swims above  
and is more penetrable, is thrust out: As  
in *Phlebotomie*, the blood which springs  
out with greater flux or force, and out of  
a greater *orifice*, and flies further, is al-  
ways thicker, fuller, and darker colour'd  
but if it flow out of a little and narrow  
hole, and by drops, (as it does out of a  
*vein* when the *ligature* is unty'd) it is  
brighter, for it is strain'd as it were, and  
only the thinner part comes out, as in the  
bleeding



bleeding at nose, or that which is extracted by Leeches or Cupping-glasses, or any way issuing by *diapedesis*, is always seen more bright; because the thicknesse and hardnesse of the *tunics* becomes more impassible, nor yeelds so plially as to give an open way for the coming out of the blood: As it likewise happens in fat bodies, when by the fat under the skin the *orifice* of the *vein* is stop'd, then the blood appears thinner, brighter, and as if it did flow from an *arterie*. On the contrary, if you receive in a sawcer the blood when you have cut an *arterie*, if it flow freely, it shall appear like *venal* blood: there is blood much brighter in the *lungs*, and squeez'd out from thence, than any is found in the *arteries*.

The emptinesse of the *arteries* in dead bodies (which did perchance cozen *Erasistratus*, insomuch that he thought that the *arteries* containd only aerial spirits) proceeds from hence, because that when the *lungs* fall (their passages being stop't) the *lungs* do breath no longer, so that the blood cannot freely passe through them, yet the *heart* continues a while in its expulsion, whence both the *left ventricle* of the *heart* is more contracted, and the *arteries* likewise empty, and not fill'd by succession of blood, appear empty: But if the *heart* cease both at one time, and the  
*lungs*

*lungs* to give passage by respiration, as it is in those who are drowned in cold water, or in those who are taken suddenly with unexpected death, you shall find both the *veins* and the *arteries* full.

As concerning the third, of the *Spirits*, what they are, and of what consistence, and how they are in the body, whether they be apart and distinct from the solid parts, or mix'd with them, there are so many and so divers opinions, that it is no wonder if *Spirits*, whose nature is left so doubtfull, do serve for a common escape to ignorance: For commonly ignorant persons when they cannot give a reason for any thing, they say presently that it is done by *Spirits*, and bring in *Spirits* as performers in all cases, and like as bad Poets, doe bring in the gods upon the Scene by head and ears, to make the *Ex.* and *Catastrophe* of their play.

*Fernelius* and others do imagine aerial *Spirits*, and invisible substances; for he proves that there are animal *Spirits* (just as *Erasistratus* proves them in the *arteries*, because there are little cells in the brains which are empty, and since there is no vacuum, he concludes, that in living men they are full of *Spirits*.

Yet all the School of Physicians agree upon three sorts of *Spirits*, that the natural *Spirits* flow through the *veins*, the vi-



tal through the *arteries*, and the animal through the *nerves*, whence the Physicians say out of *Galen*, that the parts sometimes want the consent of the brain, because the faculty, together with its essence, is sometimes hinder'd, and sometime without the essence. Over and above besides these three sorts of influxive spirits, they seem to assert so many more, which are implanted. But none of all these have we found by dissection, neither in the *veins*, *nerves*, *arteries*, nor parts of living persons. Some make corporeal Spirits, other some incorporeal Spirits; and those who make corporeal spirits sometimes say, that the blood or thinnest part of the blood is the conjunction of the soul with the body; sometimes they say, that the Spirits are containd in the blood ( as flame in smoke ) and sustain'd by the perpetuall flux of it; sometimes they do distinguish them from the blood. Those that affirm that there are Spirits incorporeal know not how to tread, but likewise doe affirm that there are potential Spirits, as Spirits concoctive, chilificative, procreative, and so many Spirits as there are faculties or parts.

But the Schoolmen tell us also of a Spirit of Fortitude, Prudence, Patience, and of all the vertues, and the most holy Spirit of wisdom, and all divine gifts. They think

think too that bad and good Spirits do : as  
 sist, possess, leave, and wander abroa  
 They think also, that diseases are caus  
 by a Devil, as by a *Cacochima*. But ea  
 though there is nothing more uncerta  
 and doubtfull, than the doctrine which  
 assign'd to us concerning the spirits : y  
 for the most part all Physicians seem wi  
*Hippocrates* to conclude, that our bodi  
 are made up of three parts, containin  
 containd, and enforcing, by the forcing  
 means Spirits. But if Spirits must be un  
 derstood to be every thing which enfor  
 ces in a mans body, whatsoever hath th  
 power or force of action in living bodie  
 must be call'd by the name of Spirits  
 Therefore all the Spirits are not aeri  
 substances, nor powers, nor habits, no  
 incorporeal.

But omitting the tediousnesse of all  
 ther significations to our purpose. Tho  
 Spirits which passe out through the *vein*  
 or the *arteries*, are not separable from th  
 blood, no more than flame from the flake  
 about it. But the blood and the Spirit sig  
 nifie the same thing, though divers in e  
 sence, as good Wine and its Spirit. Fo  
 as Wine is no more Wine after it has lo  
 its Spirit, but flat stuff or vinegar; so nei  
 ther blood without Spirit is blood, but  
 equivocally goar; as a hand of stone or  
 dead hand is no more a hand, so blood  
 with



without vital spirit is no more to be esteemed blood. So the Spirit which is chiefly in the *arteries*, and the *arterial blood* is as its act, as the Spirit of Wine in Wine, and the Spirit of *Aqua vite*, or as a little flame kindled in the Spirit of Wine, and living by nourishing of it self.

Therefore blood when it is most imbued with Spirits, it does require and look after more room, because it is swell'd or leaven'd, and blown up by them (which you may certainly judge in my experiment which I brought concerning the measure of the sawcers) but like wine, because it has greater strength and force of action and performance, in which it excels according to the mind of *Hippocrates*.

Therefore the same blood is in the *veins* which is in the *arteries*, though it be acknowledg'd to be more full of Spirit, and more eminent in vital force: but it is not converted into something more aerial or vaporous, as if there were no Spirits but aerial ones, or none that had force but such as were flatuous and windy: But neither are the Animal Spirits, natural, and vital, which are containd in the solid parts, to wit, the ligaments and nerves (especially if there be so many severall sorts of them) thought to be so many aerial forms, or divers sorts of vapours.

Those

Those who acknowledge Spirits in the bodies of creatures, but such as are corporal, but of an aerial consistence, or vaporous or fierie, of them would I faine know, Whether they can passe hither and thither, backward and forward, as distinct bodies, without the blood? Whether or no I say, the Spirits follow the motion of the blood, as if they were either parts of the blood, or adhering to it by an indissoluble connexion, and an interrupted exhalation; so that they can neither leave the parts, nor passe without the influx, reflux, and passing of the blood.

For if, as the vapours attenuated by the heat of the water, the Spirits, by the continual flux and succession of the blood become the nourishment of the parts, it will necessarily follow, that they cannot remain apart from the nourishment, but do continually vanish, for that same reason that they neither flow back nor pass any way, nor abide, but according to the influxion, refluxion, or passing of the blood, as being either their subject, *vehiculum*, or nourishment.

Then I would know, how they show us that Spirits are made in the *heart*, and do make them up, either by the compounding of exhalations, or vapours of the blood (rais'd either by the heat or compression of the *heart*.) Are not such Spi



rits to be thought much colder than the blood, since both the parts of which they are compounded, to wit, air, and vapour, are much colder? for the vapour of boiling water is much more tolerable than the water it self, and any flame burns lesse than the coal of a candle, and a wood-coal lesse than iron or brasse red hot.

Whence it seems that such Spirits doe owe their heat to the blood; rather than the blood is heated by the Spirits, and such Spirits are rather to be deem'd fumes and excrements, flowing from the blood and body, ( like smels ) than workers in Nature; especially since they being so frail and vanishing, do so quickly lose that vertue, which in their original they receive from the blood.

From whence it were likewise probable that there should be an expiration of the *lungs*, by which these Spirits being blown out might be ayr'd and purified, and that there should be an inspiration into them, that the blood passing through betwixt the *two ventricles* of the *heart* might be temper'd by the ambient cold, lest being heated, and rising and swelling with a kind of fermentation, like boiling honey or milk, it should so distend the *lungs* as to suffocate the creature, as in a dangerous *Asthma* we have often seen :

To which *Galen* likewise ascribes the reason, when he says, that this comes to passe by obstruction of the little *arteries*, namely the venous and arterious vessels. I have had experience of this, that by affixing of Cupping-glasses, and pouring upon them good store of cold water, there have many been sav'd, who have been in danger to be suffocated by an *Asthma*. I have here, perchance, spoken sufficiently concerning Spirits, which we ought to define, and show what and how they are in a Treatise of Physiologie, only I will adjoyn.

Those that speak concerning innate warmth, as an ordinary instrument of Nature in performance of all things, and tell us of the necessity of influxive heat to entertain all the parts, and keep them in life, and doe acknowledge that it cannot exist without a subject, because they find a movable bodie disproportionable by reason of the swiftnesse of the flux and reflux, ( especially in the passions of the mind ) and because of the swift motion of this heat, they introduce Spirits, as bodies most subtle, penetrative and movable, and just as they say, that from that ordinary instrument, to wit, the innate heat proceeds the admirable divinity of Natural operations: so doe they likewise affirm, that those Spirits of a sublime, bright  
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æthereal and celestial nature, are the bonds of the Soul; as the ignorant common-people when they do not conceive the reasons of things, think and say, that God is the immediate author of them.

Whence they resolve, that the influxive heat does come swiftly through all the parts, by the influx of Spirit, and that it comes through the *arteries*; as if the blood could not be so speedily mov'd, nor so fully nourish; and in the confidence of this opinion they are so far advanced, that they deny that there is any blood contained in the *arteries*.

And with very slight arguments they endeavour to ground this, that the *arterial* blood differs from the blood of the *veins*, or that the *arteries* are fill'd with such Spirits, and not with blood, contrary to all that which *Galen* both from reason and experience brought against *Erastistratus*.

But it is manifest by our former experiment, and by sense, that the *arterial* blood is not so different; the influx of the blood and Spirit with it being not separate from the blood, but that it flows in one body through the *arteries*, sense may likewise make evident.

You may observe when, and as often as the extremities of the hands, the feet, and the ears are stiff and cold, and are re-

stor'd again by the influx of heat, that it happens that at the self-same time they are colour'd, warm'd, and fill'd, and that the *veins* which were unseen before doe swell to plain appearance, from whence sometimes when they are suddenly warm'd again the parts are sensible of some pain; from which it appeats, that the same which by its influx brings heat the same is it that fills and colours them; but this can be nothing else but blood, as was demonstrated before.

Cutting off a long *arterie* or *vein* any body may see this evidently by sense when he shall see the nearer part of the *vein* towards the *heart* let out no blood but the further part pour it abundantly and nothing but blood (as afterwards in my experiment which I set down, which I tryed in the inner *jugularie veins*.) On the other side, cutting an *arterie*, but a little blood flows from the further part but the nearer part shoots with a violent force mere blood, as if it were out of a spout.

By which experiment it is known which way the passage is in them, either this way or that way. Besides, you'll know what swiftnesse there is in it, what sensible motion, not by little and by drops, and with what violence to boot.

But lest any would make an evasion, be-  
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pretending of invisible Spirits; Let the *orifice* of the vessel so dissected be let down into a vessel of water or oyl, for if any aerial thing came out, it would break out by visible bubbles; for after this manner Wasps, Hornets, and the like Insects, being drown'd or suffocate in oyl, send out at last bubbles from their tail when they are dying: from whence it is not improbable that they do take breath too whilst they are alive.

For all creatures at last when they are drown'd and stifled in the water, when they fail and sink, they use to send out bubbles out of their mouth and lungs, when they give up the ghost.

Lastly, it is assur'd by the same experiment, That the *portals* in the *veins* are so exactly shut, that air when it is blown in cannot passe; much lesse blood. I say it appears to the sense, that neither sensibly nor insensibly, neither by little, nor by drops, the blood is remov'd from the *heart* by the *veins*.

And lest any should flye hither and say thus, That this comes to passe when Nature is troubled, and does act besides Nature, not when she is left to her self, and acts at her own freedom; seeing the same things appeare in a sickly and preternatural constitution, which appear in good estate of bodie, it is not to be

said, that cutting off a *vein*, since there flows so much blood from the further part, that this comes to passe beside Nature, because Nature is molested; for the dissection does not shut the further part, so that nothing can get out that way, nor can it be squeez'd out whether Nature be troubled or no. Others doe wrangle after the same manner, saying, That although when the *arterie* is cut near the *heart* the blood breaks out in so great abundance immediatly, yet for that cause the *heart* being whole, and the *arterie* too, it does not alwayes drive the blood by impulsion. Yet it is more likely, that all impulsion does drive something, nor can there be a pulse of the container without the impulsion of something contained: Yet some, that they might defend themselves, and decline the Circulation of the blood, are not afraid to affirm and maintain this; to wit, that the *arteries* in living creatures, and being according to Nature, are so full that they cannot receive a grain weight more of blood: and so likewise of the *ventricles* of the *heart*. But it is without doubt, whensoever, or how much soever the *arteries* and *ventricles* are dilated, and contracted, they ought to receive greater impulsion of blood, and that beyond many grains. For if the *ventricles* be so distended



stended as we have seen in the Anatomie of living Creatures till they receive no more blood, the *heart* leavs beating, and continuing stiff and resisting, it occasions death by suffocation.

Whether the blood be mov'd or driven, or move it self by its own intrinsecall nature, we have spoken sufficiently in our book of the motion of the *heart* and blood; as also concerning the action, function, contraction, dilatation of the *heart*, how it is done, and together with the *Diastole* of the *arteries*, so that those which take arguments from thence for contradiction, seem either not to understand what is said there, or else they will not try the businesse by their own sight.

I believe there can not the attraction of any thing be demōstrated in the body but of the nutriment, which by succession of parts supplies by little & little that which is lost, as the oyl of a lamp by the flame.

Whence that is the first cōmon organ of all sensible attraction & impulsion, which has the nature of a *nerve*, or of a *fiber*, or of a *muscle*, to wit. that it may be contracted, and that by shortning of it self it may stretch out, draw in, or thrust forward: but these things are more fully and openly to be declared elsewhere, in the organs of motion in living creatures.

Insomuch as to those who do still reject the Circulation, because they neither see the efficient, nor finall cause of it, There remains, because I have as yet joyn'd nothing to it, only to say thus much; First you must confesse that there is a Circulation, before you enquire for what it is, for from those things that doe happen upon the circulation and allowance of it, the use and profits accrewing are to be searched. In the mean time I shall say so much, that there are many things allowed & received in Physiologie, Pathologie, and Medicine, that no body knows the cause of, yet that there are such things no body is ignorant, namely, of rotten feavers, revulsion, purgation of excrement, yet all these things are known by the help of Circulation.

Whosoever therefore does oppose the Circulation of the blood, because so long as the Circulation stands, they cannot resolve Physicall Problems, or because in curing of diseases, and using of medications, they cannot from thence assign any cause of the Symptomes, or see that those causes which from their Masters they have receiv'd, are false, or think it an unworthy thing to desert opinions approved heretofore, and think it unlawful to call in question the discipline which has been receiv'd through so many ages together



together with the authority of the Antients.

To all these I answer, that the deeds of nature, which are manifest to the sense, care not for any opinion or any antiquity, for there is nothing more antient than nature, or of greater authority.

Besides, those Problemes our of Medicinall observations not to be solv'd, as they Imagine, to the Circulation they object, and do oppose to it the declaring of their own errours, to wit, that if the circulation be true there can be no revulsion, since the blood is driven upon the part affected as before, and so it is to be feared, that there will be a passage of the excrements and blood, through the most noble and principall of our entrails. They do admire at the efflux and excretion, when out of the same body at divers holes, yea sometimes at the same hole, foul and corrupt blood issues, whereas if the blood were driven with a continuall flux, passing through the *heart*, it would be mix'd and shaken together.

They do doubt how these, and many other things that they fetch from the School of Physicians can come to pass, for they seem to be repugnant to the Circulation of the blood, nor do they think (as it is in Astronomie) that it is enough to make new Systemes, unlesse you solve all scruples.

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I thought fit to return no other answer at this time, but that the Circulation is not the same every where, and at all times, but many things do happen from the swifter or slower motion of the blood, either through the strength or infirmity of the heart, which drives it, by the abundance, estate, or constitution of the blood, the thicknesse of the parts, obstruction, and the like; thicker blood hardly finds way through narrow passages; it is more strained when it passes the streyner of the liver, than when it passes the streyner of the lungs.

It does not with a like speed passe through the thin contexture of the flesh, and *parenchyme*, as it does through the thick consistence of the nervous parts. For the thinner, more pure, and more spirituous part is sooner streynd through, the more earthy, cacochymick, and more tardy, staves longer, and is turn'd back. The nutritive part and last aliment (be it the *Ros* or *Cambium*) is more penetrative, seeing it is to be applyed to every part, whether it be to the horns, feathers, or nayls, if being every where nourished they increas in all their dimensions; for this reason the excrements in some places are voyded, thickned, or do burthen us, or are concocted: Nor do I think that there is any necessity that the excrements  
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or ill humors, being once set apart, nor the milk, flegm, nor sperm, or the last nutriment ( the *Ros* and *Cambium* ) should be return'd with the blood, but that it behooves that that which nourishes should adhere, that it may be agglutinated. Of which, and a great many other things which are to be determined and declar'd in their proper places, to wit, in Physiologie, and the rest of the parts of Physick, it is not fit to dispute, nor yet of the consequences of the Circulation of the blood, nor the conveniences nor inconveniences of it, before the Circulation it self be established for granted.

The example of Astronomie is not here to be followed, where only from appearances, and such a thing that may be, the causes, and why such a thing should be, comes to be enquir'd after. But as one desiring to know the cause of the Eclipse, ought to be plac'd above the Moon, that by his sense he might find out the cause, not by reasoning of things sensible, in things which come under the notion of the sense, no surer demonstration can be to gain beleef, than ocular testimony.

I desire that there may be one other remarkable experiment tryed by all that are desirous of the knowledge of the truth,  
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*Anatomical Exercitations, concerning*  
 by which likewise the pulse of the *arteriae*  
 is both seen to be done by the blood, and  
 evidenced to be so.

If the Gutts of a dog, or a wolf, or any Creature stuff'd, and dryed, such as you see at the Apothecaries, you cut away a part of it of any length, and fill it with water, and tie it at both ends that it is like a pudding, hitting or shaking the one end of it, in the end over against it, by putting too of your fingers (as we use to feel the pulse of the *arteriae* above the wrist) you may find every stroke and difference of the motion clearly. And after this manner in every swelling *vein* either of living or dead, you may to raw students manifest all the differences of the pulses to the sense, in greatness, frequency, vehemency, and time. For as it is in a long bladder or in a long drum, all the strokes of one of the extremes is felt likewise in the other; Therefore in the Hydropsie of the belly, as likewise in all abscessions which are fill'd with liquid matter, we use to distinguish an *Anasarca* from a *Tympanitis*; If all pulses and vibrations made in one side be by touch clearly felt in the other, we think it a *Tympanitis*, and not as it is falsely beleev'd, because it is like the sound of a drum, and is only by flatuousness, but because (as it is in a drum) every light stroke



stroke passes through it, and every shake goes through the whole; for it shews that there is a serous and wheyish substance within, and not a tough and slimy, as in the *Anasarca*, which being thrust retains the marks of the stroke or impulsion, and transmits it not. Having opened this experiment, there rises a most powerfull objection against the Circulation of the blood, neither observ'd, nor oppos'd against me by any that has hitherto written. Seeing in this experiment we see that there may be *Systoles* & *Diastoles*, without the egress of the liquor, who will beleeve but that it may be just so in the *arteries*, and that in them just so as it is in an *Euripus*, from hence thither, from thence hither, it may be driven by turns. But in another place we have sufficiently resolv'd this doubt, and now we also say, that this is not so in the *arteries* of living creatures, becaule continually and incessantly the *right ear* of the *heart* fills the *ventricles* with blood, the return of which the three-pointed *portals* hinder, and so the *left ear* fills the *left ventricle*, and both the *ventricles* in the *Systole* throw forth the blood which the *Sigmoidal portals* hinder to return, and that it ought therefore either passe some way, and continually out of the *lungs* and *arteries*, or otherwise it would

would at last by restagnation and intruſſion, break the veſſels which contain it, coſtly ſuffocate the *heart* it ſelf by diſtention, as we have obſerv'd to be plain to the ſenſe in the diſſection of a live Adder, in my Book concerning the motion of the blood.

To clear this doubt I will recite to you two experiments amongſt many other (one of which I told one before) by which it clearly appears, that the blood in the *veins*, with a continuall and great flux runs continually towards the *heart*.

In the internal *jugular vein* of a live Doe, which I laid open before a great part of the Nobility, and the King my Royal Maſter ſtanding by, which was cut and broke off in the middle: From the lower part riſing from the *Clavicule*, ſcarce a few drops did iſſue, whiſt in the mean time the blood with great force, and breaking out of a round ſtream, ran out moſt plentifully downwards from the head through the other *oriſce* of the *vein*. You may obſerve the ſame daily in Phlebotomie in the flowing out of the blood, if you hold the *vein* faſt with one finger a little below the *oriſce*, preſently the flux is ſtopped, which after you let it go flows abundantly, as before.

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In any visible long *vein* of your arm, stretching out your hand, and pressing out all the blood downwards as much as you can, you shall see the *vein* fall, leaving as it were a furrow in the place, but so soon as you thrust it back with one of your fingers, you shall presently see the part towards the hand, to be fill'd, and swell, and to rise by the return of the blood from the hand. What is the reason, that by stopping of the breath, and by that means streightning the *lungs*, and a great deal of air being within, the pectorall vessells are streightned, whence the blood is driven into the face, and eyes, with so much rednesse?

Nay that (as *Aristotle* says in his *Problemes*) all actions are perform'd with greater strength by keeping in of the breath, than by letting it free? so you get blood more abundantly out of the *veins* of the *brow*, or *tongue*, by compression of the throat, and retention of breath.

I have found sometimes in a mans body, newly hang'd, 2 hours after his execution, before the rednesse of his face was gon, opening up his *heart* and *Pericardium*, the *right ear* of his *heart*, and *lungs* much stuffed, and distended with blood, many witnesses standing by, especially I shew'd them the *ear*, as big  
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as a mans fist, so swel'd, that you would have thought it would have burst with greatnesse, which, the body being afterwards cold, and the blood having found other ways, was quite gone.

So from these, and other experiments it is clear enough, that the blood runs through all the *veins* to the *basis* of the *heart*, and that unlesse it found passage it behov'd to be streightned; or shut up in other ways, and that the *heart* would be o'whelmed with it, as on the other part, if it did not flow out of the *arteries*, but were regurgitated, the oppression by it would quickly appear.

I will add another observation: A noble Knight Baronet Sir *Robert Darcie* father to the Son-in-Law of the most learned man, and my very great friend, and a famous Physician, Dr. *Argent*, about the middle of his age, did often complain of an oppressive pain in his breast, especially in the night time, so that sometimes being afraid of collapsion of spirits, sometimes fearing suffocation by a Paroxisme, he led an unquiet and anxious life, using the Counsell of all Physicians, and taking many things in vain, at last the disease prevailing, he becomes cachectick, and Hydropick, and at last oppressed in a signall Paroxism he died, In his Corps, in the presence of Dr. *Argent*, who



who at that time was President of the College of Physicians, and Dr. Gorge, a rare Divine, and a good Preacher, who was at that time Minister of that Parish, by the hinderance of the passage of the blood out of the *left ventricle* into the *arteries*, the wall of the *left ventricle* it self (which is seen to be thick and strong enough) was broken, and poured forth blood at a wide hole, for it was a hole so big, that it would easily receive one of my fingers.

I knew another stout man, who did so boyl with rage because he had suffer'd an injury, and receiv'd an affront by one that was more powerfull than himself, that his anger and hatred being increas'd every day (by reason he could not be reveng'd) and discovering the passion of his mind to no body, which was so exulcerate within him, at last he fell into a strange sort of a disease, and was tortur'd, and miserably tormented with great oppression and pain in his *heart*, and brest, so that the most skilfull Physicians prescriptions doing no good upon him, at last, after some years, he fell sick of the Scorbutick disease, pin'd away, and dyed.

This man only found ease as oft as his brest was prest down by a strong man, and was thump'd and beaten down as they do when they mould bread: his friends

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thought he was bewitch'd, or possess'd with the Devil.

He likewise had his *jugular arteries* distended about the greatnesse of ones thumbs, as if either of them had been the *Aorta* it self, or the *Arteria magna* in its descent, and did beat vehemently, and were to the view like two long Aneurisms, which caus'd us try blood-letting in his temples, but that gave him no ease. In his corps I found the *heart* and the *aorta* so distended and full of blood, that the bignesse of his *heart*, and the concavities of the *ventricles*, were equall in bignesse to that of an Oxe; so great is the strength of the blood when it is shut up, and so vast its force.

Although then ( by the experiment newly mention'd ) there may be an impulsion without an exite (in the shaking of water up and down ) in the pudding afore-mentioned, yet cannot it be so in the blood which is in the vessels of living persons, without very great and heavy impediments and dangers.

Yet from thence it is manifest, that the blood in its Circulation does not passe every where with the same agility and swiftnesse, nor with the same vehemence in all places and parts, and at all times, but that it varies much according to the age, sex, temper, habit of body, and other contingents, external, internal, natural, or preternatural. For



For it does not pass through the crooked and obstructed passages, with the same swiftnesse as it does through those that are open, free, and patent; nor does it passe through bodies or dense parts, and such as are stuff'd or constricted, as it does through those that are thin, open, and without obstruction; nor does it run out so swiftly and penetratively when the impulsion is flow and soft, as when it is driven with force and strength, and thrust forward with vehemency and abundance. Nor is the thick blood or solid masse, or when it is made earthy, so penetrative, as when it is more wheyish, made thin, and liquid.

And therefore with reason we may imagine, that the blood in its Circulation goes flowlier through the *veins*, than through the substance of the *heart*; swiftlier through the *liver*, than through the *veins*; swiftlier through the *spleen*, than through the *liver*; swiftlier through the *lungs*, than through the flesh, or any other viscera of thinner contexture.

We may likewise contemplate in the age, sex, temperature, habit of the body soft or hard, of the ambient cold, which condenses bodies, when the *veins* scarce appear in the members, or the sanguine colour is seen, or the heat appears, the blood being made more liquid by reception of nutriment. So like-

wise the *veins* do more conspicuously, and freely pour out the blood the body being heated before opening of a *vein* than when it is cold. We see that the passion of the mind ( in the administration of Phlebotomie ) if any fearfull person chance to sound, streight the flux of the blood is stopp'd, and a bloodless paleness seizes on all the superficie of his body, his members are stiff, his ears sing, his eyes grow dim, and are in convulsion. I find here a field where I might run out further, and exspatiate at large in speculation: But from hence so great a light of truth appears, from which so many questions may be resolv'd, so many doubts answered, so many causes and cures of diseases found out, that they seem to require a particular treatise. Concerning all which in my medicinal observations, I'll set down things worthy your admiration.

For what is more admirable, than that in all affections, desires, hope, or fear, our bodies suffer severall ways, our very countenances are changed, and our blood is seen to fly up and down? with anger our eyes are red, the black of the eye is lessen'd in shamefastnesse, and the cheeks are flush'd with rednesse; in fear, infamie, and shame, the face pale, the ears glow, as if they should hear some ill thing: Young men that are toucht



touch'd with lust, how quickly is their *nerve* fill'd with blood, erected and extended? But it is most worthy the observation of Physicians, why blood-letting and cupping glasses, and the stopping of the *arterie* which carries the flux (especially whilst they are doing) does as it were with a charm take away all pain and grief: I say, such things as these are to be referred to observations, where they are explained clearly.

Frivolous and unexperienced persons do scurvily strive to overthrow by logical, and far-fetch'd arguments, or to establish such things as are meerly to be confirm'd by Anatomical dissection, and ocular testimony. It behoves him, who ever is desirous to learn, to see any thing which is in question, if it be obvious to sense, and sight, whether it be so or no, or else be bound to believe those that have made tryall, for by no other clearer or more evident certainty can he learn or be taught. Who will perswade a man that has not tasted them, that sweet or new wine is better than water? with what arguments shall one perswade a blind man that the Sun is clear, and out-shines all the Stars in the firmament? So concerning the Circulation of the blood, which all have had confirm'd to them for so many years, by so many ocular experiments, there has been hi-  
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*Anatomical Exercitations, concerning*  
 therto no man found, who by his observations could refute a thing so obvious to the sense (to wit the motion of flux and reflux) by observations alike obvious to the sense, or destroy the confirm'd experience of it, nay by ocular testimony none ever offer'd to build up a contrary opinion.

Whilst in the mean time there are not wanting persons, who for their unskillfullnesse, and little experience in Anatomy, having nothing agreeable to sense to oppose to it, they cavill at it with some vain assertions, and such as they adhere to from the authority of Teachers, with no solid supposition, but with idle and frivolous arguments, and bark at it besides with a great many other words, and those base ones too with rayling, and base scurvy language, by which they do no more than shew their own vanity, and folly, and their baseness, and want of arguments, which are to be fetch'd from sense, so that they with their false Sophisticall arguments do rage against sense: Just as when the raging winds advancing the waves in the *Sicilian* Sea dashes them in pieces against the rocks within *Charybdis*, they make a hideous noise, and being broken and reverberated hiss, and foam, so do these men rage against the reason of their own sense.



If nothing should be admitted by sense without the testimony of reason, or sometimes against the dictate of reason, there should be no question now to be controverted.

If our most certain Authors were not our senses, and these things were to be established by reasoning, as the Geometricians do in their frames, we should truly admit of no Science, for it is the rationall demonstration of Geometrie from things sensible to demonstrate things to the sense, according to which example, things abstruse, and hid from the sense, grow more manifest by things which are easier, and better known. *Aristotle* advises us much better *lib. 31 de Gen. Anim.* disputing of the generation of Bees, says he, *you must give credit to your senses; if those things which are demonstrated to you are agreeable to those things which are perceptible by sense, which, as they shall then be better known, so you may better trust your sense than your reason.* Whence we ought to approve or reject all things by examination leisurely made, but if you will examine or try whether they be said right or wrong, you must bring them to the test of sense, and confirm, and establish them by the judgement of sense, where, if there be any thing feignd or not, sure it will appear. Whence *Plato* says in his *Critias*, That the explication of

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*Anatomical Exercitations, concerning*  
those things is not hard, of which we can come to the experiment, nor are those auditors fit for Science, that have no experience.

How hard and difficult a thing is it for those that have no experience, to teach such things of which they have no experience, or sensible knowledge; and how unfit and indocile unexperienced Auditors are to true Science, the judgement of blind-men in colours, and of deaf men in the distinctiō of sounds, dos plainly shew. Who shall ever teach the flux and reflux of the Sea? or by a Geometrical Diagram teach the quantities of Angles, or the computation of the sides of a figure to a blind-man, or to those that never saw the Sea, nor a Diagram? A man that is not expert in Anatomie, in so far as he cannot conceive the businesse with his own eyes, and proper reach, in so far is thought to be blind to learning, and unfit; for he knows not truly any thing concerning which an Anatomist disputes, nor any thing, from the implanted nature of which he should take his argument, but all things he is alike ignorant of, as well those things which are gathered and concluded, as the things from whence. But there is no possible knowledge, which arrives not from a pre-existent knowledge, and that very demonstrable. This one cause is the chief reason why the knowledge



ledge we have of the heavenly bodies is so uncertain and conjectural. Very faine would I know from those ignorant persons, that professe the causes and reasons of all things, why as both the eys in beholding move together every way, nor particularly one moves this way, and the other that way, so neither both the *ears* of the *heart*?

Because they know not the causes of fevers, or of the plague, or the admirable properties of some medicaments, and the causes why they are so, must therefore these things be denied?

Why is the Birth that breaths not till the tenth moneth, not suffocated for want of ayr? since one that is born in the seventh or eighth, so soon as he has breathed in the air, is presently choak'd if it have no air? How can it retain life whilst it is yet within the *Secundine*, or as yet not come forth, without breath? but so soon as he comes into the air unlesse he breath he cannot live?

Because I see many men doubtful in the Circulation, and some men oppose such things which understand them not aright, as I intended them, I shall briefly reherse out of my Book of the motion of the *heart* and blood, what I did there intend. The blood which is containd in the *veins* (as in its own hold) where it is most abundant (to wit, in the *vena cava*) near to  
the

*Anatomical Exercitations, concerning*  
the *Basis* of the *heart*, and the *right ear*,  
growing hot by little and little by its  
own internal heat, and made thin, it swells  
and rises (like leaven) whence the *ear*  
being first dilated, and afterwards con-  
tracting it self by its pulsifick faculty,  
streightways drives it out into the *right*  
*ventricle* of the *heart*, which being fill'd  
in its *Systole*, and consequently freeing it-  
self from that blood which is driven into  
it (the three-pointed *portals* refusing pas-  
sage to it) it drives the same blood into  
the *vena arteriosa* (where the passage is  
open) by which it does distend it. Now  
the blood in the *arterious vessel* being not  
able to return against the *Sigmoidal por-*  
*tals*, but because the *lungs* are extended,  
amplified, and restricted both by inspira-  
tion and expiration, and likewise their  
vessels, they give passage to this blood in-  
to the *arteria venosa*: of which the *left ear*  
keeping together equal motion, time and  
order, with the *right ear*, and perform-  
ing its function, sends the same blood  
into the *left ventricle*, as the *right*  
sent into the *right*, whence the *left*  
*ventricle* together, and at the same time  
with the *right* (since it can gain no re-  
gresse, by reason of the *portalls* which  
hinder its return) drives it into the ca-  
paciousnesse of the *aorta*, and conse-  
quently into all the branches of the *arte-*  
*rie*; the *arteries* being filled with this  
sud-



sudden pulse, being not able so suddenly to disburthen themselves, are distended, suffer an impulsions and *Diastole*.

Whence I gather, seeing the same is reiterated continually and incessantly, that the *arteries*, both in the *lungs*, and in the whole body, by so many stroaks, and impulsions of the *heart*, would be so distended and stuffed with blood, at least that either the impulsions would give over all together, or else the *arteries* would burst, or be so dilated, that they would contain the whole masse of blood which is in the *veins*, unlesse the efflux of blood were disburthen'd somewhere.

We may likewise reason after the same manner of the *ventricles* of the *heart*, being fill'd & stuff'd with blood, unlesse the *arteries* did likewise disburthen, they would be at last distended and destitute of all motion. This consequence of mine is demonstrative and true, and followes of necessity, if the premises be true; but our senses ought to assure us whether such things be false or true, and not our reason, ocular testimony, and no contemplation.

I affirm likewise of the blood in the *veins*, that the blood does always, and every where, run out of the lesse into the greater, and hastens towards the *heart* from every part: whence I gather, that  
what-

whatsoever quantitie which is continually sent in, the *arteries* do receive by the *veins*, that the same does return and does at last flow back thither from whence it is first driven, and that by this means the blood moves circularly, being driven in its flux and reflux by the *heart*, by whose force it is driven into all the *fibers* of the *arteries*, and that it does afterwards successively, by a continuall flux return through the *veins*, from all those parts which draw, and streyn it through; sense it self teaches us that this is true, and collections from things obvious to sense takes away all occasion of doubt.

Lastly, this is that I did endeavour to relate and lay open by my observations and experiments, and not to demonstrate by causes and probable principles, but to confirm it by sense and experience, as by a powerfull authority, according to the rule of Anatomists.

From these we may observe what force, and violence, and strong vehemencie we perceive in the *heart*, and greater *arteries* by touch & sight. I do not say, that in all the vessels which contain the blood, the pulse of the *Systole* and *Diastole* is the same (in greater Creatures) nor in all creatures which have blood, but that there is such a one and so great in all, that by that means there is a flux of blood, and  
swifter



swifter course of it through the small *arteries*, the porosities of the parts and branches of all the *veins*, and from thence comes the Circulation: for neither the small *arteries*, nor the *veins* do beat, but only the *arteries* which are nighest to the *heart*, because they do not so soon send the blood out, as it is driven into them, for you may try, opening of an *arterie*, if the blood leap out in full stream, so that it come out as freely as it went in, that you scarce found any pulse in that *arterie* through which it passes, because the blood running through, and finding passage, does not distend it. In Fishes, Serpents, and colder creatures, the *heart* beats slowlie and weaker, that you will hardly perceive any pulse in the *arteries*, because they passe their blood through very slowlie; whence it is that in these as also in the little fibers of the *arteries* of a man there is no distinction by blood; because they are not pierc'd with impulsion of blood.

As I said before, the blood that passes through an *arterie* which is cut and opened, makes no pulse there at all; whence it clearly appears, that the *arteries* suffer their *Diastole* neither by innate pulsifick faculty, nor by any granted them from the *heart*, but by the meer impulsion of the blood. For in the full flux, flowing out the length of its course, you may by touch

touch perceive both the *Systole* and *Dia-*  
*stole*, as I said before, and all the diffe-  
rences of the pulse of the *heart*, their time,  
order, vehemency, intermission in the  
emanation of the flux evidently, (as it  
were in a looking-glass.) Just as water, by  
the force and impulsions of a spout is dri-  
ven aloft through pipes of lead, we may  
observe and distinguish all the forcings of  
the Engine, though you be a good way  
off, in the flux of the water when it passes  
out, the order, beginning, increase, end,  
and vehemency of every motion. Even  
so it is when you cut off the orifice of an  
*arterie*; where you must observe, That  
as in the water, the flux is continuall;  
though it be sometimes nigher, sometimes  
further: so in the *arteries*, besides the  
shaking, pulse, and concussion of the  
blood, (which is not equally to be percei-  
ved in all) from that time forward there  
is a continual motion and fluxion in  
the blood, till the blood be again retur-  
ned to that place where it first began,  
thatis to say, to the *right ear*.

These things you may try at your plea-  
sure cutting up one of the longer *arteries*,  
(as the *jugular*) which if you take be-  
twixt your fingers, you shall clearly dis-  
cern how it loses its pulse and recovers it  
again, beats lesse or more. And as these  
things may be tryed whilst the brest is  
whole; so opening the brest, and the  
*lungs*



17.  
*lungs* afterwards being collaps'd, and all motion of respiration gone, you may easily try it, to wit, that the *left ear* is contracted and empty'd, that it becomes more whitish, and that it doth at last, together with the *left ventricle*, intermit in its pulse, beat leisurely, and at last leave off: And likewise by the hole which you may cut in the *arterie*, you may see the blood come forth lesse and lesse in a smaller thred, and that at last, (to wit, in the defect of blood, and the impulsion of the *left ventricle*) no more will flow.

You may likewise try this same in the tying of the *vena arteriosa*, and so take away the pulse of the *left ear*, and with untying it, restore the pulse at your pleasure. Whence the same thing is evidently try'd by experiment, which is seen in dying persons, that as first the *left ventricle* desists from motion and pulse, and afterwards the *left ear*, then the *right ventricle*, & pulse, lastly, the *right ear*; so where the vital faculty begins first, it ends last.

Which being tried by the sense, it is manifest, that the blood passes only through the *septum* of the *heart*, and not through the *lungs*, and only through them whilst they are mov'd in respiration, and not when they are fallen or disquieted. For which cause in an *Embryon* (not as yet breathing) Nature instead of the passage in the *arteria venosa*, (that matter may be

be furnish'd to the *left ventricle*, and the *left ear*) opens an oval hole, which shuts in young men, and those that breathe freely.

It likewise appears, why those that have the vessels of their *lungs* oppress'd, and stuff'd, or those that have any losse of their breath, it is present token of death.

It is likewise clear, why the blood of the *lungs* is so flame-colour'd; for it is thinnest that is strain'd through there. It is besides to be observ'd from our former conclusion, in order to those who require the causes of Circulation, & think the power of the *heart* to be the effecter of all things, and as it is the author of transmission by pulse, so with *Aristotle* they think it the author of attraction, and generation of blood, and that the Spirits are made by the *heart*, and the influxive heat (& that by the innat heat of the *heart*, as by the immediate instrument of the soul, or by a common bond and the first organ for perfecting of all the works of life. And so the motion of the blood and spirit, its perfection and heat, and every property thereof, to be borrow'd from the *heart*, and from its beginning; (which *Arist.* says is in the blood, as in hot water, or boyling pottage) is in the *heart*, and that it is the first cause of pulsation and life. If I may speak freely, I do not think that these things are so (as they are commonly believed).



ved) for there are many things which persuade me to that opinion, which I will take notice of in the generation of creatures, which are not fit here to be rehearsed; but it may be things more wonderful than these, and such as will give more light to natural Philosophie, shall be publish'd by me.

Yet in the mean time I will say and propound it without demonstration, (with the leave of most learned men, and reverence to antiquity) that the *heart*, as it is the beginning of all things in the body, the spring, fountain, and first causer of life, is so to be taken, as being joyn'd, together with the *veins*, and all the *arteries*, and the blood which is contain'd in thē. Like as the *brain*, (together with all its sensible *nervus*, *organs*, and *spinal marrow*) is the adequate organ of the sense, (as the phrase is.) But if you understand by this word *heart*, the body of the *heart*, with the *ventricles* and *ears*, I do not think it to be the framer of the blood, and that it has not force, vertue, motion, or heat, as the gift of the *heart*; and next, that the same is not the cause of the *Diaστοle* & distention. which is the cause of the *Συστοle* and contraction, whether in the *ears* or *arteries*: but that part of the pulse which is call'd a *Diaστοle* comes of another cause, diverse from the *Συστοle*, and ought to go before every *Συστοle*. I think the first cause of distention is innate heat in the blood it self, which (like leaven) by little and little at-

tenuated and swelling, is the last thing that is extinct in the creature. I agree to *Aristotles* instance of pottage, or milk, in so far as he thinks that elevation or depression of the blood does not come of vapours or exhalations, or Spirits rais'd into a vaporous or aerial form, nor is not caus'd by any external agent, but by the regulating of Nature, an internal principle.

Nor is the *heart* ( as some think ) like charcoal-fire ( like a hot Kettle ) the beginning of heat and blood , but rather the blood delivers that heat which it has receiv'd to the *heart* , as likewise to all the rest of the parts , as being the hottest of all. Therefore *arteries* , and the *coronary veins* are assign'd to the *heart* for that use which they are assign'd to the rest of the parts , to wit , for influx of heat for the entertaining and conservation of it, therefore all the hotter parts , how much more sanguine they are , and more abundant with blood, they are said convertibly so to be , and thus the *heart* having signall cavities, is to be thought the Ware-house of continuall fire, and fountain of the blood not because of the corpulency of it, but because of the blood which it contains like a hot Kettle, as in the same manner the *spleen* , *lungs*, and other parts are thought hot , because they have many *veins* or vessels containing blood.

And after this manner do I believe th



the native heat, call'd innate, to be the first efficient cause of pulse, as likewise to be the common instrument of all operations. This as yet I do not constantly aver, but propound it as a *Thesis*; I would fain know what may be objected by good and learned men, without scurrilitie of words, reproaches, or base language, and any body shall be welcome to do it.

These things then are as it were the parts and the footsteps of the passage, and Circulation of the blood; to wit, from the right ear into the *ventricle*, out of the *ventricle* through the *lungs* into the *left ear*, then into the *left ventricle*, into the *aorta*, and into all the *arteries* from the *heart*, by the porosities of the parts into the *veins*, and by the *veins* into the *Basis* of the *heart*, the blood returns most spedily.

By an experiment any man may try that pleases by the *veins*, let the arm be tyed as the custome is with a gentle ligature, and let it remain tyed so long, still moving the arm up and down, till the *veins* all of them swell exceedingly, and the skin grow very red below the *ligature*. and then let the hand be washed with Snow or cold water, till the blood gatherd below the *ligature* be cold enough, then presently untying the ligature, you shall find by the cold blood which returns how swiftly it runs back to the *heart*, and what a change it will make in its return thither, so

that it is not to be wondred at, that in the untying of the ligature in blood letting, some have sounded. This experiment does demonstrate that the *veins* below the ligature do not swell with blood attenuated, and puffed up with spirit, but with blood only, and such blood which can be reverberated into the *arteries* through the Anastomosis of the parts, or the hidden *Meanders*.

It likewise shews how those that passe over snowy mountains, are often suddenly seized with death, and many such like.

Lest it should seem a difficult businesse, how the blood should passe through the *pores* of the parts, and go hither and thither, I will add one experiment. It happens after the same manner to those that are strangled, and hang'd with a rope, as it does in the tying of the arm, that beyond the cord their face, eyes, lips, tongue, and all the upper parts of their head are stuff'd, with very much blood, grow extream red, and swell till they look black, in such a carcase untying the rope, in whatsoever position you set it, within a very few hours you shall see all the blood leave the face and the head, and see it as it were fall down with its own weight, from the upper to the lower parts through the *pores* of the skin and flesh, and the rest of the parts, and that it fills all the parts below and the skin chiefly, & colours



it with black matter; how much more lively and sprightly the blood is in a living body, and by how much more penetrating it is through the porosities than congealed blood, especially when it is condens'd through all the habit of the body, by the cold of death, the ways too being stopp'd and hinder'd, so much the more easie and ready is the passage in those that are alive through all the parts.

*Renatus de Cartes* a most acute and ingenious man (to whom for his honourable mentioning of my name I am much indebted) and others with him, when they see the heart of a fish taken out placed upon an even board imitate a pulse (by collecting it self) in its erection, up-lifting, vigoration, they think that it is amplified, and dilated, and that the *ventricles* of it become more capacious, not according to my opinion. For when it is gathered, at that time, the capacities of it are rather streightned, and it is certain that it is then in its *Sistole*, and not in its *Diastole*, as neither when it falls weak and flagging, and is relax'd, it is then in its *Diastole*, or distention, and thence the *ventricles* become wider; so in a dead man we do not say that his heart is in the *Diastole*, because it is flagging without any *Systole*, destitute of all manner of motion, and not distended at all, for it is distended properly, and is in the *Diastole* when it is fill'd

by the impulsion of the blood, and contraction of the *ear*, as in the *Anatomic* of living things is evident enough.

Therefore they understand not how much the relaxation, and falling of the *heart* and *arteries* differ from their distention and *Diastole*; that distention, relaxation, and constriction, come not of the same causes, but from contrary causes, as making contrary effects; and diverse, as making divers motions, as all Anatomists know very well, that the opposite *muscles* in any part (called *Antagonistæ*) are the causes of severall motions, to wit, of adduction, and extension, so there is necessarily by nature fram'd contrarie, and divers active organs, for contrary and divers motions.

Nor dos this efficient cause of pulse which he sets down according to *Aristotle* please me, to wit, that the ebullition of the blood shall be both the cause of the *Systole*, and of the *Diastole*. For these motions are sudden stroaks, and swift hits. And there is nothing that swells so like leaven, or boyls up so suddenly in the twinkling of an eye. and falls again, but that rises leisurely, and falls suddenly; besides, in dissection you may by your own eye-sight discern, that the *ventricles* of the *heart* are distended, and fill'd by the constriction of the *ears*, and are encreas'd in bignesse according as they are fill'd, more or lesse, and that the distention  
of



of the *heart* is a kind of violent motion, done by impulsions, not by an attraction.

There are some who think, as there is no need of impulsions for the aliment in the nourishing of Plants, but it is by little and little drawn into the place of that which is spent by the indigent parts; so the vegetive faculty performs its work alike in both, but there is a difference. Calid influxive is continually requir'd to the entertaining of the members of creatures, and preserving of vivifying heat in them, and for restoring of the parts which suffer by outward injury, and not for nutrition onely.

So much of Circulation, which if it be not duely perform'd, or be hinder'd or perverted, or go too swiftly, there follows many dangerous sorts of diseases, and admirable symptoms, either in the *veins*, as swellings, abscessions, griefs, hæmeroids, flux of blood, or in the *arteries*, as swellings, boyls, strong and pricking pains, aneurisms, tumors in the flesh, fluxions, sudden suffocations, *asthma's*, stupidity, apoplexy, and others innumerable. Likewise it is not fit to tel in this place, how as it were with an Enchantment, many things are cur'd, and taken away, which were thought incurable.

I may set down such things in my medicinal observations, and discourses of Pathologie, which I have hitherto known to be observ'd by none.

I will conclude (most learned *Riolan*) to  
give

give you more ample satisfaction, because you think that there is no Circulation in the *mesentericks*; Let the *vena porta* be tied neerer to the *cymus* of the *liver* in a live dissection, which you may easily try, you shall see by the swelling of the *veins* beneath the *ligature*, that same come to pass which happens in blood-letting by tying of the arm, which will show you the passage of the blood there.

And when you shall hear any man of that opinion, that by *Anastomosis* the blood can come out of the *veins* into the *arteries*, tie in a live dissection the great *vein*, near the division of the *crurals*, and as soon as you cut the *arterie* (because it finds passage) you shall see all the masse of blood emptied out of all the *veins* (nay out of the *ascendent cava* too) by the pulse of the *heart*, in a very short time, yet that below the *ligature* the *crural veins* & parts below are only full. Which, if it could any way have returned into the *arteries* by an *Anastomosis*, should never have come to passe.

*FINIS.*



